POWER

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Ask the Engineer

MAN is an imitative creature. Almost everything that he does is done because somebody else did it. And when he has to do something, instead of studying out the best way to do it in the circumstances, he looks around to see how somebody else did it and does it that way.

It may be the best way that it could be done, but if it is it will be by accident.

And if it is not, the fact that he had a good example or precedent will not pay the damage.

The most effective argument that some salesmen can use is that a friend or competitor of the prospect has bought their goods.

"The same" was said to be the most popular American drink in the days when there were such things.

Conditions differ. New ways of doing things are being developed all the time. New materials and apparatus are constantly being brought out.

I heard a bright executive once say that when he was called upon to decide a proposition he asked himself three questions:

Should it be done at all?

Should it be done now?

Should it be done in the way proposed?

The last question can be answered only after a full consideration of all the available ways, and these can be considered only in the light of a knowledge of the newest and best methods, materials and apparatus for effecting the given purpose.

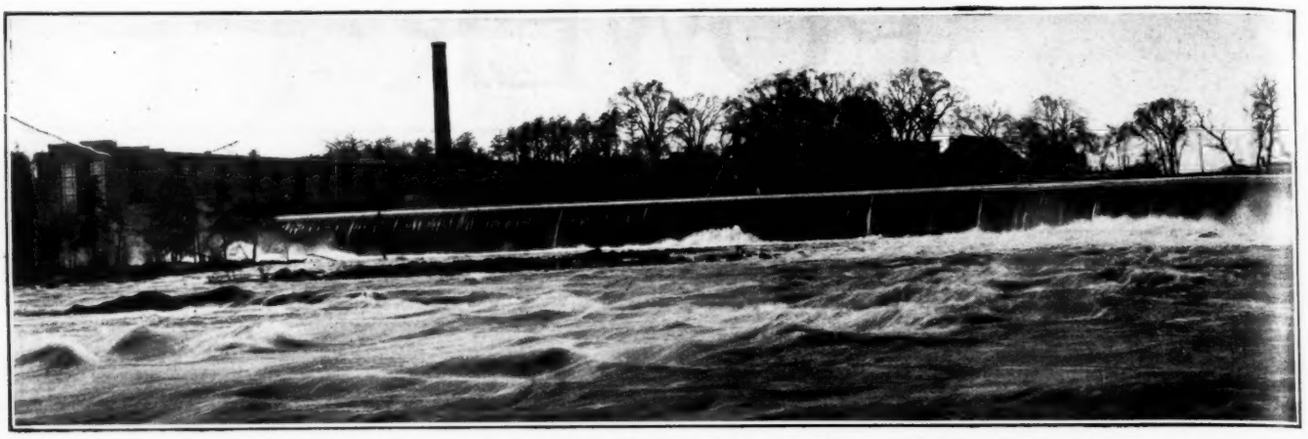
Too many power plants are put together by this practice of following suit. The owner buys one piece of apparatus after another because somebody else did.

And he often gets a motley collection.

If the man who runs or is going to run your plant is one of the up-to-date sort who knows the characteristics and limitations of the materials and apparatus used in his business, who knows not only the apparatus that he has run himself but what is available and the results that have been obtained with it in other plants, he will be your best adviser.

F. R. Low

Ask the engineer.



NEW POWER HOUSE ON THE LEFT; WATER FROM FOREBAY RUNNING OVER DAM

Redevelopment of One of New England's Oldest Water Powers*

By ARTHUR T. SAFFORD†

A WATER power that has been used over one hundred years for driving textile mills has recently been redeveloped by the Amoskeag Manufacturing Co., Manchester, N. H., by installing three 7,500-hp. units in a new hydro-electric station in place of fifty wheels of small capacity used in the old installation. The old wheels, headgates and canals will be retained to utilize surplus water during freshet periods. This development will eventually result in obtaining about 100 per cent more power from the Merrimack River than with the old wheels alone and, with plans for building a dam and power house eight miles below Manchester, has been designed for an eventual complete use of the Merrimack River at Amoskeag and Moore's Falls. The study of redeveloping Amoskeag Falls included plans for developing Moore's Falls because the pond of the latter will back water to Manchester.

NEW ENGLAND having been favored with many water powers comparatively easy to develop on navigable rivers, became a great industrial center early in the history of this country. In those early days there were no means of transportation excepting boats and no way of transmitting power other than by belts, gears and shafting; our present efficient and convenient electrical systems of long-distance transmission and distribution of power had not even become a dream. As a result it was necessary to build manufacturing plants near the rivers and waterfalls and utilize the water for power in wheels of a size best suited to the fall and needs of the mill. Since the power requirements of the individual factory were comparatively small, it resulted in the development of the water power by using small units, many of which are still in existence.

The water powers were at first sufficient to supply the needs of the industries, but eventually the demand exceeded that available from water and the growth was met by the introduction of the steam engine. The development of the Amoskeag Manufacturing Co. water power at Amoskeag Falls on the Merrimack River, Manchester, N. H., is a good example of the conditions that have grown out of New England's textile industry. This company's mills have increased in size until now about 800,000 spindles and 20,000 looms are operated, requiring 40,000 hp. When the water was available, 15,000 hp. of this was supplied by waterwheels; the remainder was supplied by steam and required approximately 100,000 tons of coal per year for power and process steam purposes.

The high price of fuel and the difficulties of obtaining it made desirable the developing of more power from the water available than was possible with the existing canal system and a large number of small wheels. This redevelopment had its origin about 1918 in the minds of the treasurer, F. C. Dumaine, and H. F. Straw, then agent of the Amoskeag Manufacturing Co., when they asked the writer to suggest how they might best utilize the Merrimack River. This was one of the many instances in New England where the seeds of conservation had fallen on fertile ground, already prepared by a growing interest in water power and increasing costs of coal and labor. Many preliminary plans were made to show what might be done with one or more surplus power units of about 1,000 hp. each, to be added to the old Amoskeag canal development. All these plans were finally abandoned for a new hydro-electric station, to use all the water during the lowest and average month's flow, through large modern wheels, thereby gradually making the present old wheels surplus power units, to run at times when the flow was above normal.

In the early part of 1919 the work was started and has been carried on practically continuously except for high water particularly in 1919, until now, when two of three 7,500-hp. units are running. The machines

*Based on a paper presented before the Boston Society of Civil Engineers.

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show by their performance and the net head under which they are operating that they will develop power well beyond their rated capacity. To make this development during two years of unusual flow with freshets coming almost every month, has required the closest attention on the part of the Amoskeag's engineers and superintendents, under the direction of Perry Dow in planning the work.

The site of this new development, on the west channel of Amoskeag Falls (see Fig. 1), the earliest developments there and the subsequent canal development on the east side about 1831, have so much historic interest that a description of these is essential to a complete story of the power at Amoskeag Falls. There are three great falls of the Merrimack River—at Manchester, Lowell and Lawrence—all developed for cotton and woolen manufacturing on a large scale and known from the earliest colonial times.

Early Power Development at Amoskeag Falls

In 1810 there was a mill and village called Amoskeag on the west side of the river and a saw and grist mill near the foot of the rapids of the west channel; portions of the foundations of the mill and tailrace are either there now or have been removed only to meet the requirements of the new plant. The wheels were either overshot or of the tub type, made by local millwrights and of small capacity. In 1830 the Amoskeag company had acquired all the rights to the land and water power on both sides of the Merrimack River at Amoskeag Falls and for distance of a mile or more below, sold land and water power to the Stark Mills and expected to sell other mill sites and water power; but, having built and operated a mill of their own as early as 1831, they went into manufacturing, gradually built mill after mill and enlarged their plant until it now occupies in all about 140 acres and 6,000,000 sq.ft. of floor space in buildings on both sides of the Merrimack River.

The first water-power development at Manchester, like those of Holyoke, Lewiston, Lowell, Lawrence, was by canals, which were located to make mill sites available with water power, the power being figured in mill powers so-called. A mill power was the water required to run an early mill, at Waltham, Mass., containing 3,584 spindles, spinning No. 14 yarn, with all the apparatus necessary to convert the cotton into cloth. This was taken as the standard for the mill power; in water it was the right to draw 25 cu.ft. per sec. at a fall of 30 ft., equal, according to James B. Francis, to about 60 hp., for which the price fixed on was $4 a spindle, or $14,336 for a mill power and as much land as was proper for the establishment. A mill power was about 80 gross horsepower, but with the type of wheel used, measured at the switchboard not more than 50 electrical horsepower.

Fig. 1 shows the Amoskeag mills as they are today and the power canal system started in 1831. The old wheels are arranged in groups, some drawing water from the upper canal, some from the lower, and one group taking water from the upper canal, through penstocks under the lower canal, discharging directly into the river. This is a horizontal-wheel plant well designed and of the best type of horizontal end discharge wheels of twenty-five years ago. Tests of these old wheels show at the switchboard an efficiency varying from more than 50 to 75 per cent of the gross power of the water. The final result from the new hydro-electric plant will be a more efficient use of the low and normal flow of the river with a gain of perhaps one-third in the amount of power developed besides use of more water during the high-water periods than the total used prior to 1923.

Equipment Installed in Old Plants

The canals were built as they were and as far apart to provide mill sites, and each wheel or group of wheels drove a mill or mills. Formerly, these wheels and the engines of twenty years ago were connected through heavy shafts; and although everything was of the best design for the times and all bearings were installed with self-oiling devices, the shafting load must have been very large.

The old system contained not only 50 wheels in 27 groups, but as many headgates, penstocks, tailraces and other machinery necessary for their operation. The average rating of all the units was about 300 hp., but one group, the Jefferson, which operated under the lower canal, developed upward of 1,200 hp. The units in the new hydro-station are rated at 7,500 hp. each, and two of them will develop just about as much power as all the old wheels together. It is intended that all the old wheels will continue to run when there is surplus water available, and a few of them will be operated days and nights until the mills are entirely electrified. The last 10 per cent will probably be electrified within the next five years.

Amoskeag has led in electrification among the older mills, and the building of the new plant found the mills

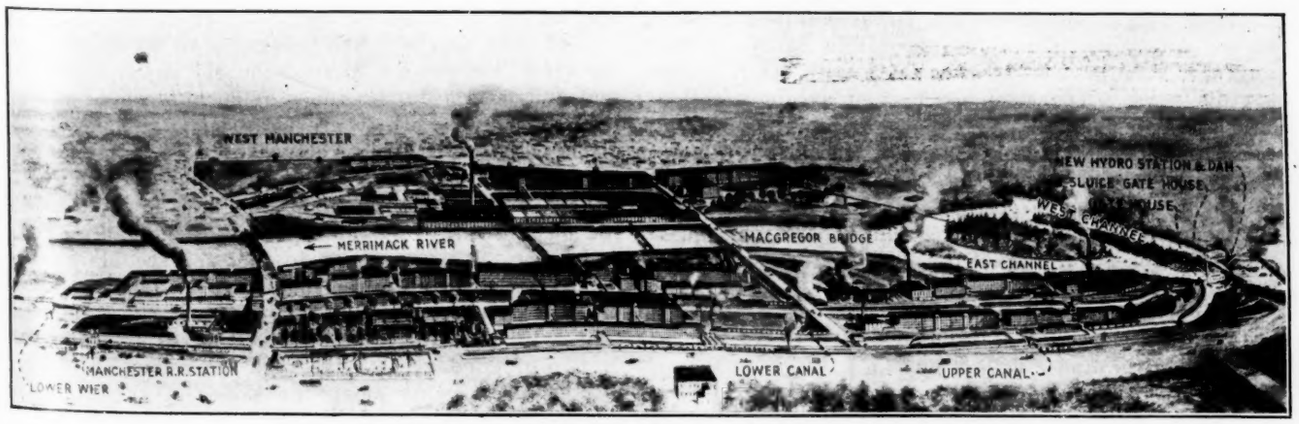


FIG. 1—LOCATION OF WATER-POWER DEVELOPMENTS AND MILLS
In the old development water is taken from the upper and lower canals, through wheels in the various mills. The new power house is located in the west channel and takes water directly from the river and will contain three 7,500-hp. vertical-shaft turbines.

about three-quarters electrified with synchronous generators on the mainshafts to take up the valleys of the load. The few remaining water-power units of the old developments will be gradually electrified but run only with surplus power. In connection with the new work, however, a central station has been built with lines coming from and radiating to every source of power and use. In addition to the present generating units provision has been made for lines from Moore's Falls, eight miles below, which may be developed if coal remains high and New England prosperous.

The company had a maximum water-power output of about 15,000 hp., with a minimum of about 5,000 hp., engine capacity of about 40,000 hp. and boiler capacity

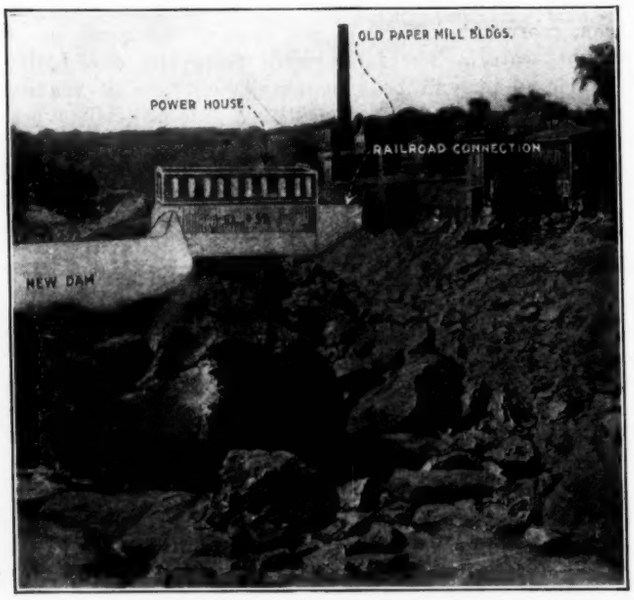


FIG. 2—NEW POWER HOUSE FORMS PART OF DAM
Power house and dam have been painted in on a photograph taken previous to their erection.

for about 10,000 hp. more than this, which supplied steam to processes. There are three main divisions of steam power—the northern, central and southern divisions—all electrified.

There was little cheap electric power in large blocks available from outside sources which the company might have contracted for; the ordinary price for blocks of approximately 1,000 kw. appeared to be about 1.6c. per kw.-hr., or $45 per kilowatt for the textile year of 2,800 hours. Steam-electric power can be generated at the Amoskeag plants for about this figure, so that any new water power must compete with steam power at this price. The company has an arrangement by which it can supply or take power from the Traction Company, at a price that in time will probably take all the available power from the river that cannot be used for manufacturing purposes, which is upward of 40,000 hp. when the mills are running full. There is no question, therefore, of a market for all the water power that the river will furnish.

The extremes of freshet and drought at Manchester are from 60,000 sec.ft. to about 800; the snowfall, particularly in the upper valleys and on the hills, is heavy, varying from 40 to 100 in.; the ice breaks up occasionally when hard and thick, subjecting every structure to the hardest kind of usage; but with the old and new development it will be possible, without further storage, to utilize about 50 per cent of the total run-off of the stream mentioned.

The amount of storage above Manchester is about 10 billion cubic feet, most of which is in Winnipiseogee Lake and good for about 500 sec.-ft., 24 hours per day, in addition to the run-off from the unstored area. Plans are being developed for a possible increase in storage amounting to another 10 billion cubic feet, but it will be expensive.

The millpond above Manchester contains about 43,000,000 cu.ft. with 3 ft. draw-down, or just about enough to store 1,000 sec.-ft. for 12 hours or 1,500 sec.-ft. for 8 hours. As the Amoskeag, however, has and probably will run a part of its mills nights to use the night flow, there is very little loss of water because of the relatively small capacity of the millpond.

The problem given the engineers was to use the present dam or build a new one, construct a new canal, station and install turbines which should, as far as is possible, develop the full capacity of the generators (5,000 kw. each) at 0.8 power factor under all conditions of water, on a stream that is subject to sudden rises, protracted droughts and where water storage so far built is but one-tenth of the total run-off. The total fall from the top of the old dam to the river at times of low flow is over 50 ft. Formerly, the head was reduced by headgates during freshets when the back-water rose from a few feet to twenty feet. The design of the new plant will bring the water at all stages of flow directly to the station and the backwater relatively will be much less of a handicap as it comes out of one fall instead of two, and digging out of the tailrace, the last important part of the work to be completed, will also improve this condition.

Studies Made of Redevelopment

Many sites were studied for the redevelopment. With the idea that any redevelopment might be simply for surplus power, there were a good many locations on the east side where additional power could be generated at a comparatively low cost for wheels, generators and settings; but it was found that where the canals were large enough the river bed was high, and where the river was lower the canals had already been overtaxed in capacity. The plan selected makes of the west channel of the river a canal, cuts off the west channel by the new hydro-electric station and spillway dam up river and across to the present old gatehouse on the east side (see Figs. 1 and 2).

The new dam will flood a dam built in 1871, which will be cut down a few feet in order to eliminate any loss of head over it. The headgates on the east side of the river will remain to feed the old power canal system and wheels during times of surplus water and the new sluice gates, which are located on that side of the river. The old locking gates have been renewed with stronger lift gates to help out the sluice gates, which will have a capacity of about 4,000 sec.-ft. and enable the flashboards to be retained with less chance of loss and labor. It is proposed to increase the Manchester pond, particularly in the winter, by additional flashboards if arrangements can be made. It has been found that, with the mill pond frozen, it takes an extra foot or two of pondage to make good the reduction of area by the ice freezing along the slopes of the shores of the river.

Work began in the fall of 1919, but the equipment, turbines, generators, governors and headgate hoists

were not ordered until the spring of the following year. High water and the textile strike of 1922 added several months each to the length of the job, but otherwise it was continuous until finished in the late fall of 1922. But two units have been installed; however, the speed rings and pit liner have been set for the third.

The dam is in two parts, one stretch 400 ft. long at elevation 72 (Fig. 2) from the power house up river and the rest 340 ft. long at elevation 70 from this point to the old gatehouse, which has been reinforced by a new abutment facing up the old to elevation 82. It is expected that two- and four-foot flashboards will be maintained on the new dam, bringing the structure during low and normal stages of the river to elevation 74. by the division of practically 50 ft. fall into the requirements of each 5,000-kw. unit.

The power house is at right angles to the new dam (see Fig. 2) and on foundations that are on the same granite ledges that form the foundation of the new dam. Because of the width of the west channel at the site of the station, it is longer than is necessary for the three units, switchboard and auxiliaries; but as the branch railroad track on the west side led directly to the boiler house of an old paper mill and could be extended directly into the station, there was no particular advantage in making the station less than 200 ft. long. There is one intermediate floor or basement at the level of the turbine gates. This basement will be

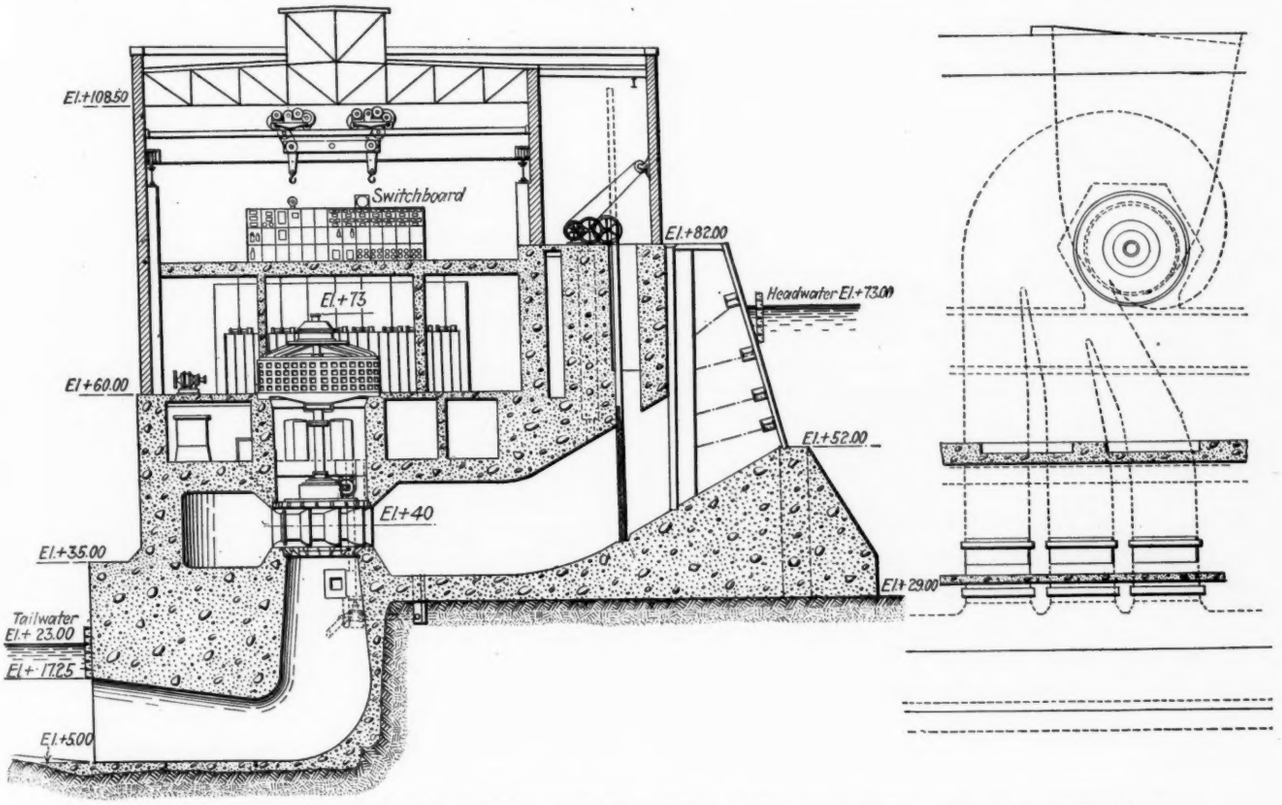


FIG. 3—PLANT LAID OUT FOR THREE 7,500-HP. UNITS; TWO OF WHICH ARE NOW INSTALLED

The section of the dam is of solid concrete, excepting the cable and inspection tunnel, and compares well in weight and stability with the other dams on this and the Connecticut Rivers.

The rack dam at elevation 52 (Figs. 2 and 3) which forms the lowest cutoff, is continuous across the west channel and bonded into the ledge on both sides. It is of solid concrete and doweled to the ledge under it. The racks, headgates and hoists are of regular design, but the hoists are motor driven and the gates covered by the roof of the power house. The scrolls are of concrete with thin tapering partitions, three each 10 ft. wide by 20 ft. high (Fig. 3) and conform to the measurements which the turbine manufacturers laid down.

The power house is of brick, approximately 200x65 ft. and 62 ft. high above the generator floor at elevation 60. The height of the building in the clear was fixed by the lift of the motor-driven crane, which lifts 55 ft. from the generator floor. The draft tubes at elevation 17.25, the center of the wheel openings at elevation 40 and the top of the generator at elevation 73 are all fixed used for storage and to house the transformers for the 30,000-volt power lines from the Traction Co. and outgoing 2,300-volt circuits to the Coolidge Mill and to the tunnel in the dam.

The west end of the power house opens to receive a standard-gage track and unloading platform within reach of the crane. In spacing the units, two wheels are installed in the westerly half of the power house and one in the easterly half on account of a rock island in the west channel.

The turbines were built by I. P. Morris and include all the improvements in gate mechanism and governing which this company and its subsidiaries offered. The rating is 7,500 hp. 112.5 r.p.m., with 46-ft. head when using 1,700 cu.ft.-sec. of water. The design of scrolls and draft tubes, with some few exceptions, were submitted by them, and the turbines are guaranteed for 89 per cent efficiency. The generators were furnished by the General Electric Co. under an efficiency guarantee of 95 per cent at 0.80 power factor. Under the present conditions of fall and flow, which are not yet

as good as can be obtained, one machine has already developed for a short time as high as 5,900 kw. at 0.9 gate opening. Current is generated at 2,300 volts three phase 60 cycles, and the ordinary mill loads will be distributed at this voltage. The switchboard is carried on a mezzanine floor on the east end of the power house.

The fall from the crest of the new dam at elevation 70 to tailwater below the Macgregor bridge (Fig. 1) when the mills are shut down and very little water is running, is 50 ft. or more. Between this bridge and the new station there were a number of bars of ledge and gravel which altogether used up about 10 ft. of head. The station was designed with draft tubes at elevation 17.25 and tailwater at elevation 26, for 46 ft. head when all three units are running.

The company controls an undeveloped power site at Moore's Falls, 8 miles below Manchester, and the height of this dam has been tentatively fixed at elevation 16 and flashboards at 24. To get the rest of this fall nearly down to the top of the proposed Moore's Falls flashboards, it was necessary to blast and clean out a channel 200 ft. wide for a distance about 1,000 ft. below the new station, which required removing about 100,000 cu.yd. of material.

Estimate of Power Possibilities

The output of the 1831 and later developments, up to the building of the new station is a question, but can be estimated approximately. On May 3, 1921, the "total water power" from the mill records was: 8 a.m., 15,439 hp.; 11 a.m., 15,374 hp.; 2 p.m., 15,214 hp.; 4 p.m., 15,310 hp.; an average of 15,334 hp., which may be considered a maximum.

On Sept. 13, 1921, the total water power from the same records are: 8 a.m., 8,522 hp.; 11 a.m., 7,527 hp.; 2 p.m., 6,664 hp.; 4 p.m., 7,112 hp.; an average of 7,456 hp.

If the Amoskeag got as a rough average six months at 15,334 hp. and six months at 7,456 hp., the yearly average would be 11,395, or 31,906,000 hp.-hr. per year. Adding to this night running by the Jefferson wheels of about 1,200 hp. for 3,000 hours may be considered as having produced an additional 3,600,000 hp.-hr. which makes a total of 35,500,000 hp.-hr. per year.

Based on the flow for four years preceding the building of the new station, and the pondage, headwater and tailwater, as they were and are to be expected when both the new station[1] and the old wheels are running, the following figures are my estimate of the output:

ESTIMATES OF POWER OBTAINABLE FROM OLD AND NEW PLANTS

Years	Old Wheels, Hp.-Hr.	New Hydro-Station, Hp.-Hr.	Total New and Old Plants, Hp.-Hr.
1915	36,860,000	25,260,000	62,120,000
1916	37,850,000	30,650,000	68,500,000
1917	34,390,000	27,560,000	61,950,000
1918	34,630,000	23,810,000	58,440,000
Average	35,932,000	26,820,000	62,752,000

The existing conditions make it fair to assume that the figures given, 62,752,000 hp.-hr. are likely to be realized from two units and an additional 6,000,000 hp.-hr. with three units running. In kilowatt-hours this means in round numbers 50 million in an average year. During the period from 1911 to 1914, however, the flow of the Merrimack River was very low; and a repetition of years like these will cut the output materially.

The work was handled by the Amoskeag engineering organization by day labor, which was increased to meet the requirements of a job of this size. This organization has built foundations and installed hydraulic, mechanical and electrical machinery for years.

The author expresses his thanks to the officials of the Amoskeag Manufacturing Co., particularly the present agent, W. P. Straw, for his kindness in supplying necessary data and suggestions from his operating department.

[1]Two units now installed and running.

Charging a Refrigerating System

By C. H. Lloyd

There have been so many methods of charging a refrigerating plant with ammonia that are tedious or inaccurate that the correct way should be outlined for the benefit of young engineers.

Suppose one begins with a new and entirely empty system. When the plant has been all tested out with compressed air and found tight, a vacuum should be pumped on the entire system including the evaporating coils and condensers, to remove all the air. An ammonia cylinder is then attached to the liquid line between the receiver and the expansion coils and its valve or cock opened. The compressor should be stopped, and all connecting valves between expansion coils and condenser should be left open. When the pressure in the system has risen somewhat, the valve between the receiver and the expansion coils directly at the receiver should be closed and the water started over the condensers. The compressor should now be started and run sufficiently fast to keep the expansion coils at a pressure of 5 or 6 lb. gage. This is low enough to clear the cylinder of all liquid, which will be indicated by frost on the pipe attaching the cylinder to the line and on the cylinder bottom at the low or outlet end. This should be kept up until enough cylinders are charged to start operation of the plant, the number depending upon the size of the system.

After starting the plant, probably as much as one-third more ammonia will be required to have the system fully charged. The refrigerator or brine tank, whichever is used, being warm, will not require as much ammonia at the start as later on, for the evaporation at first is much more rapid. As the charge lowers in the receiver, more ammonia should be added in the manner outlined until the receiver gage shows one-third to one-half full when the plant is in full operation. In replenishing a low charge, connect the cylinder to the charging valve between the receiver and evaporating coils and when ready simply close the master valve at the receiver and open the ones from the cylinder. None of the other valves on the system should be disturbed unless the pressure in the evaporating coils should run below 5 or 6 lb. gage. If the pressure does drop, the compressor should be slowed down or, if electrically driven, stopped until the pressure rises slightly. Do not pump a vacuum, as this is liable to draw in air around the rod and at other joints. The ammonia cylinders should be weighed both when full and when empty, to be sure that all the ammonia is drained out. Should there be any doubt regarding the quality of the ammonia, it would be well to draw a sample into a testing bottle and try it for evaporation. In drawing the sample, be very careful that no condensation from the pipe through which the sample is drawn is allowed to drip into the test bottle. The residue after the ammonia evaporates, is the amount of impurities.

Operating Alternating-Current Generators in Parallel

BY RALPH BROWN*

AFTER discussing the operation of a single alternator two or more machines operating in parallel are treated of, showing the effects of changing the field current and speed of the machines.

OPERATING generators and transmission systems in parallel is a logical though radically different method from that originally followed, when care was taken to avoid parallel operation. This article, written from the viewpoint of the practical operator or engineer, deals with the parallel operation of alternating-current generators. A second article will treat of operating other classes of alternating-current equipment in parallel. Fig. 1 shows a single-wire diagram, with disconnectors omitted, of a transmission line and step-up and step-down transformers connected to one generator. This is the simplest arrangement possible where power transformers are used, and owing to the impossibility of supplying uninterrupted service from a single generator, this scheme can be used only where it is possible occasionally to allow a complete suspension of service.

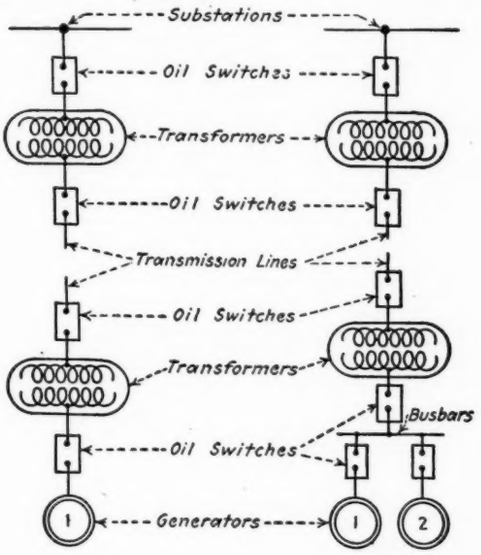


Fig. 1 Fig. 2

FIGS. 1 AND 2—ONE-LINE DIAGRAM OF ALTERNATING-CURRENT GENERATOR CONNECTIONS

Fig. 1—One line diagram of a single alternator connected through transformers to its load. Fig. 2—Two alternators connected in parallel and through transformers to their load.

Assuming that all equipment indicated in Fig. 1 is in operative condition, the substation could be energized by bringing the generator to rated speed on governor control, cutting in the generator voltage regulator if one is used, and closing the generator switch at no-load voltage. Lighting of the lamps at the substation will indicate that full load may be applied, and as load is connected, the governor of the prime mover driving the generator will maintain it at normal speed and frequency unless overloaded, and if a line-drop compensator is used in connection with the generator voltage regulator, the voltage will be maintained constant at the substation.

The kilowatt, or true, load of such a generator will practically always be delivered at a power factor of less than 100 per cent, probably averaging 80 per cent, if, as would generally be the case, the load consisted entirely of induction motors and lights. Because the power factor, which is the ratio of the true to the apparent watts, affects the heating and voltage regulation of an alternating-current generator, such generators are properly rated in kilovolt-amperes instead of in kilowatts, and are loaded with reference to their kilovolt-ampere rating and temperature. In Fig. 1 the generator power factor at normal frequency and voltage depends entirely on the nature of the load and is beyond the control of the operators.

CONSTANT FREQUENCY DESIRABLE

Because apparatus designed to operate at a definite frequency operates best at that frequency, the frequency must be maintained within close limits, a variation as great as 1 per cent above or below normal being unusual on large systems. However, where a single generator is the only source of power on an isolated system, such close regulation cannot be expected, but if the prime mover is a hydraulic turbine, the governor can be adjusted to maintain practically a constant frequency, except for momentary variations, from no-load to full-load without any attention on the part of the operator. Where the prime mover is a steam turbine or engine, such close regulation is not possible, and unless adjustments are made the frequency may vary from 2 to 5 per cent. By adjusting the governor so that normal frequency will be obtained at about 50 per cent load, the frequency will remain within one or two per cent plus or minus of normal without adjustment.

Fig. 2 shows one-line connections suitable for two-generator operation, and it is assumed that No. 1 generator is in operation, that all connections for No. 2 generator, which is similar to No. 1, are correct, governor adjustments properly made, and that this generator is to be paralleled with No. 1. Before the generators are paralleled, they must be in synchronism, which means that the frequency, voltage and phase relations of No. 2, the incoming generator, must agree exactly with those of the bus to which No. 1, the running machine, is connected.

Synchronism is generally indicated by a synchroscope, with lamps connected as a check. The movable pointer of the synchroscope remains stationary in the upright position when the incoming machine is in synchronism, at which time the synchronizing lamps may be either bright or dark, depending on the con-

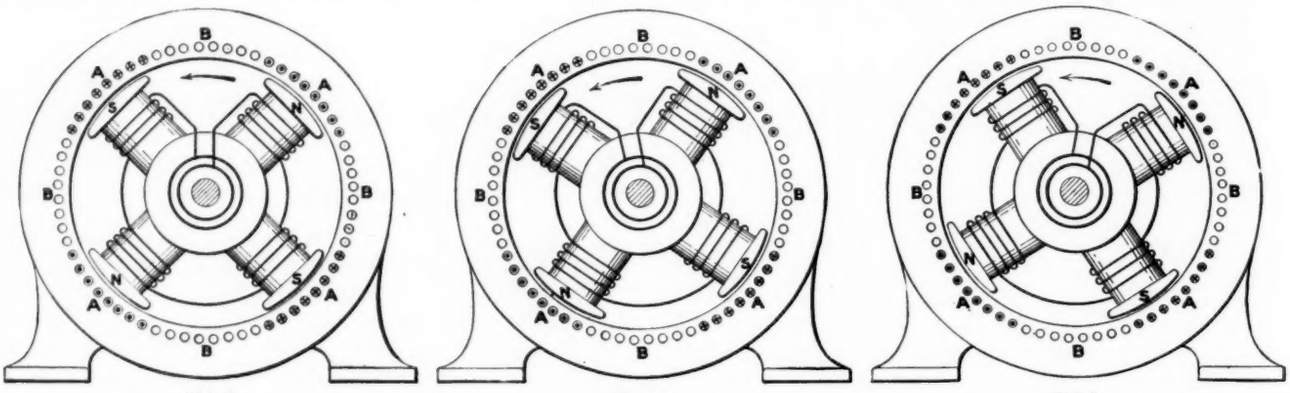
*The Great Western Power Company.

nections. The direction of rotation of the pointer indicates whether the incoming machine is fast or slow, and the speed of rotation depends on the difference between the frequencies. To avoid possible damage to the synchroscope because of excessive speed, it should not be connected if the difference between the frequencies exceeds 3 cycles under which conditions the pointer would make 3 revolutions per second. The synchroscope should never be left in circuit, because of possible heating. When synchronizing, it is of course necessary to operate the switch so that contacts will close when the generators are exactly in synchronism, and the time interval required to accomplish this depends on the speed of the synchroscope pointer, type and capacity of the switch, and the condition of the switch operating mechanism. A slight difference between the voltages of the bus and the incoming generator will cause but little disturbance when they are synchronized, but a phase displacement of 8 or 10 deg. will generally cause an objectionable rush of current between the machines. The maximum flow of current occurs when a generator is paralleled 180 deg. out of phase, such a connection being equivalent to a short-circuit. Since the mechanical stresses imposed on the armature windings and intervening conductors vary as the square of the current, it is evident that for this reason alone synchronizing must be carefully done.

After No. 2 generator has been synchronized and is operating in parallel with No. 1, with no change in the system load or power factor, it will be possible to change the power factor and load on each generator. In fact, after paralleling, the operator would probably at once increase the load on No. 2, by adjusting its governor to tend to cause an increase in speed, at the same time decreasing it on No. 1 generator by adjusting its governor to tend to cause a decrease in speed, the total load depending on the energy required at the substation. If the prime mover of No. 2 generator is caused to develop power and take load from No. 1 machine, the frequency of the system will increase owing to an increase in speed, which will occur when load is taken off No. 1 generator.

In order that prime movers shall, when operated in parallel, automatically assume loads proportional to their respective capacities, it is necessary that their governors be adjusted so that a permanent decrease in speed is produced from no load to full load. This speed change is generally 2 per cent to 4 per cent of normal speed; that is, if a generator operated at 60 cycles, or 1,800 r.p.m. at full load, and a complete rejection, or loss of load occurred, if the governor was adjusted for a 4 per cent speed change, at no load the generator would operate at 1,872 r.p.m., or 62.4 cycles. In order that the frequency shall remain constant, it is necessary for the operators to change, usually by means of motor control, the setting of the governors that are maintaining the frequency of generators operating in parallel. Hence, as the load is increased on No. 2 generator, a change would be required in the speed setting of No. 1 governor to prevent the frequency increasing appreciably above normal.

Depending on conditions, the governors of any number of generators operating in parallel may maintain the frequency, or only a few may be used for this purpose, the remainder being set to hold a constant load and functioning only on the occurrence of high or low speed. If the governors of the two generators indicated in Fig. 2 were adjusted to maintain the frequency, No. 1 generator could be made to assume more load by simply adjusting its governor to tend to operate at a higher speed. Since the generators are in parallel, they must operate at exactly the same frequency, hence the effect of a higher speed setting is to shift the field poles of this generator a few electrical degrees in the direction of rotation, with reference to those of No. 2 generator. For example, if Fig. 3 shows the position of the poles of No. 2 generator at a given instant, then if No. 1 generator is made to carry more load than No. 2, its polepieces will take some such position as in Fig. 4. Since both machines have the same number of poles, they must run at the same speed, but causing No. 1 generator to tend to run faster than No. 2, its field poles are shifted slightly ahead of those of No. 2, which cause No. 1 to take more load. With the load and power factor of each generator equal the field poles would be in line, but if unequally loaded the field poles of the generator developing the smaller amount of power would lag a few degrees behind those of the other generator; as for example, the poles of the machine, Fig. 5, lag behind those of the generator, Fig. 3. If full load



FIGS. 3 TO 5—SHOW RELATION BETWEEN POSITION OF THE FIELD POLES OF ALTERNATORS OPERATING IN PARALLEL WHEN ONE MACHINE IS CARRYING MORE LOAD THAN ANOTHER

If machines Figs. 3 and 4 are operating in parallel and the governor of the prime mover driving the machine Fig. 4 is adjusted to cause it to tend to increase in speed and take more load, both machines will continue to run at the same speed, but the field poles of the machine Fig. 4 will be shifted in angular position slightly ahead of those of the machine Fig. 3. If the governor of the prime mover driving machine Fig. 4 were to be adjusted to cause the machines to decrease in speed and take less load than the machine Fig. 3, the two machines would still run at the same speed, but the field poles of the machine carrying the least load would lag in angular position behind those of the machine carrying the largest load, as the field poles of the machine Fig. 5 lag in angular position behind those of Fig. 3. The diagrams represent two-phase machines.

were transferred from No. 2 to No. 1 generator, its revolving parts would be possibly 60 electrical degrees in advance of those of No. 2 generator.

Were it not for the synchronizing power which causes generators to remain in synchronism, the prime mover with the highest-speed setting would actually drive its generator at a higher speed and frequency than the one with a lower speed setting. It is not an uncommon occurrence for a generator to fall out of synchronism, or step, during disturbances accompanied by low bus voltage, and even large generators will pull into synchronism of their own accord. If a generator that is out of step does not quickly return to synchronism, it must be disconnected from the bus and synchronized in the usual manner.

If, as sometimes happens, control of a prime mover is lost, as in a hydro-electric plant, it may attain a dangerous speed, and all rotating apparatus operating in parallel with it will also be subjected to increased speed. If the generator at fault is not disconnected, the alternative is to disconnect any equipment supplied by the machine before a destructive speed is reached.

Distribution of Armature Current

Now that the distribution of the kilowatt load of generators operating in parallel and frequency regulation have been dealt with, the distribution of the armature current may be considered. With No. 1 generator only (Fig. 2) in operation, its armature current is a fixed quantity depending entirely on the load, but after No. 2 generator is synchronized conditions are different, and the armature current and power factor of each generator can be varied through wide limits. Assuming that No. 2 generator has just been paralleled and is lightly loaded, if its field current is increased while the field current of No. 1 generator is decreased, the armature current of No. 2 generator will increase without the bus voltage being affected. At the same time the power factor of No. 1 generator will increase, and unless originally too low, it can be made 100 per cent. No. 2 generator in this case would be supplying a part of the load current and all the wattless current. When two or more generators are operating in parallel at a constant load and voltage, it will be found that their armature currents can be changed by changing their field currents. This is due to cross-currents that are established when the field currents are such that each generator supplies other than its proper share of the wattless current required. If two generators are operated on a bus with all load disconnected, it is evident that load current cannot flow, but even with equal field currents a small amount of current would flow between the generators to keep them in synchronism. If the field currents were made unequal, their armature currents would increase, and full-load current at a very low power factor could be caused to circulate between the two generators by creating sufficient difference in the field current of the two machines.

Relation of Load and Power Factor

Generators of identical characteristics and rating will always assume their proper share of wattless current if their field currents are equal, but their respective power factors will not agree except when their kilowatt outputs are equal. With two generators operating with a lagging power factor and equal field currents, the machine supplying the more power will operate at the higher power factor. With several generators operating in parallel with lagging power factors, a reduction in the field strength of one of them will be accompanied by an increase in the power factor of this generator, while the power factors of the other generators will decrease. The power factor of one generator can generally be made unity, with a leading power factor resulting if the field current is decreased after unity power factor is indicated. The armature current is thus controlled by changing the field currents of generators operating in parallel, the larger, cooler machines generally supplying the greater portion of the current at a low power factor, thus relieving the smaller generators of wattless current. Under conditions of low power factor generators are frequently operated as synchronous motors with over-excited fields for power-factor correction, this being accomplished by reducing or entirely cutting off the power supply to their prime movers. When motoring turbo-generator sets, the steam must not be entirely cut off, or damage is likely to result due to overheating of the blading.

Power Factor Can Be Changed by Adjusting Field Current

If generators are to be operated so that the wattless current is equally divided between them, their field currents must be adjusted so that for proportionally equal loads their power factors will be identical. If power-factor indicators are not provided, the power factor can be easily calculated provided that wattmeter and ammeter readings are available. Equal division of wattless current between the generators is indicated when the sum of the armature ammeter readings is the minimum that can be obtained. If the power factor of a generator operating in parallel with others is lagging, an increase in its field current will be accompanied by an increase in its armature current, but if leading, an increase in field current will cause a reduction in the armature current; however, a change in field current will have no effect on the kilowatt output. As explained in the foregoing, the kilowatt output of each machine is controlled by governor adjustment.

The voltage of an alternator operating at constant frequency depends on its effective field strength, and owing to the impedance of the armature, decreases as load is applied. Principally by reason of its weakening effect on the field flux lagging current will cause a marked decrease in voltage, while the opposite is true if the armature current is leading; for example, a generator supplying charging current to a long transmission line may produce full voltage at zero field current. The voltage is controlled either manually or by automatic generator voltage regulators, and regulators can be so connected that they will cause each generator to share properly the wattless current.

Baking of surface condensers as part of the cleaning process is sometimes resorted to and is done by opening doors in the waterboxes to allow a full circulation of air and at the same time admitting steam to the steam space of the condenser. The steam admitted is regulated so as to bring the temperature to 180 deg. F., at which point it is maintained for two hours. By this procedure accumulations on the inside of the tubes are dried, curl up and peel off and are carried out by the circulating water when the unit goes into service. This method has the objection that it may cause the tube packing to loosen up and leak.

Wind Pressure in Chimney Design

Formulas Compared—What Wind Velocity and Base Pressure to Choose—Live Load Produced by Wind Conditions

By W. WALLACE CHRISTIE*

IT IS necessary, in designing a chimney or other structure, to ascertain the highest wind velocity that is ever likely to be reached in that locality and from this to determine the resulting wind pressure. In the United States it is customary to use a single value for wind pressure corresponding to the estimated velocity throughout the entire height of the stack. In Europe designers consider that the wind velocity, and therefore pressure, increases from the base upward toward the top of the shaft. Some engineers, however, have used an average value for all parts of the shaft. The calculations of chimney design should be based on the actual conditions of wind pressure which increases upward from the base to the top of the shaft. Formulas will first be taken up, and then the constants of ground pressure and allowable maximum wind velocity; these constants are compared by using different values in the formulas, worked out in tables.

If the pressure of wind against a flat surface is taken as unity, then that on a round shaft is 0.67 and on an octagonal shaft, 0.71, according to the constants in general use. It is possible that greater wind pressures than 25, 30 or even 40 lb. per sq.ft. have been recorded, but such phenomena will not necessarily be used as the basis for calculation, any more than disturbances caused by earthquakes, etc.

Lang's Method for Determining Average Wind Pressure

The Lang formula for figuring the average wind pressures is based on the assumption that the actual pressures increase at a constant ratio from the base to the top, and therefore the wind pressure at any velocity may be calculated at any desired height. The equation itself is worked out to give the average value of wind pressures between the base and the top. The result of this equation is in accord with those reported from experiments and also with that of foreign formulas, and is therefore considered as a satisfactory working formula. This is $E = e + 0.0373\ H$. E represents the average wind pressure throughout the stack, e equals the wind pressure at the ground level of the chimney and H represents the height of the chimney in feet. A similar formula giving actual wind pressure at any desired height, however, is $W = e + 0.0466\ H$., where W is the actual wind pressure at the height H in feet.

Value of Wind Pressure at the Base of the Stack

Actual observation indicates that a pressure of 20.45 lb. per sq.ft. is reasonable for some uses, but for the smallest chimneys a value of not less than 25.57 to 26 lb. per sq.ft. should be used when calculating the average value of wind pressure from Lang's formula. Table I indicates the average wind pressure for types of stacks, using both 22.5 lb. per sq.ft. and 30.7 lb. per sq.ft. as wind pressure at the base, substituted for e in this formula. The smaller value is correct for buildings a distance from the coast in protected localities, but the latter value is more suitable for unfavorable circumstances, such as on the coast and exposed at high altitudes.

TABLE I—AVERAGE WIND PRESSURE, LB. PER SQ.FT. FROM LANG'S FORMULA

Height In Feet	Average Pressures $e = 22.5$	Lb. Per Sq.Ft $e = 30.7$
65.6	24.95	33.15
131.2	27.40	35.60
262.4	32.30	40.50

The wireless shaft at Tokio, which is 672 ft. high, should have a wind pressure at the top of 51.76 lb. per sq.ft., assuming 20.45 lb. as base pressure and using the formula $W = e + 0.0466\ H$. If, however, the base pressure is assumed to be 30 lb. per sq.ft., as used in the United States, then the pressure at the top would be 61.31 lb. per sq.ft. The actual assumptions used in the design of this shaft are given at 60 lb. at the ground or base and 126 at the top, which are about twice the calculated values.

Wind pressures at the top of stacks of various heights are indicated in Table II, using base pressures of both 22.5 lb. per sq.ft. and 30.7 lb. per sq.ft., which corresponds to the worst conditions recorded in Germany or Austria. The lowest ground pressure used in foreign countries is 20.45 lb. per sq.ft.

TABLE II—WIND PRESSURE AT THE TOP OF THE STACK, LB. PER SQ.FT.

Height In Feet	$e = 22.5$	$e = 30.7$
65.60	25.56	33.76
131.20	28.62	36.82
262.40	34.72	42.94

Wind Velocities.

Wind velocities are usually measured by Robinson's anemometer, having crossarms fitted with cups, which is the most reliable apparatus in general use, but is known to give results approximately 30 per cent higher than real or true velocity at the higher ranges. In Vienna, 80.53 miles per hour was the highest velocity observed from 1871 to 1884. In Hamburg, Germany, the same velocity is reported in the vicinity of the most violent storms. If we deduct from this 30 per cent, we will have 55.37 miles per hour or 15.35 lb. per sq.ft.

Wind Velocities Produce a "Live" Load

In the design of the Great Falls (Montana) chimney completed in October, 1908, and which is 50 ft. diameter (nominal) by 506 ft. high, 125 miles per hour wind velocity was used, which gives 50 lb. per sq.ft. on flat projection, or 33.33 lb. per sq.ft. on circular projection, and 35 lb. per sq.ft. on octagonal projection. Using 30.7 lb. at the base in the previous formula would give us 54.11 lb. per sq.ft. at a height of 506 feet.

L. T. Samuels, in *Monthly Weather Review*, vol. 50, p. 83, says that from more than 2,400 balloon tests he

*Consulting engineer, Ridgewood, N. J. Author "Chimney Design and Theory."

has arrived at certain conclusions as to the velocity of free air at various heights; for chimneys the author, has taken Samuels formula for the worst conditions recorded, 111.84 miles per hour, wind velocity at the base, and has these velocities at elevations given:

TABLE III—WIND VELOCITIES FROM BALLOON TESTS

738 ft. elevation	176.93 miles per hour
2,460 ft. elevation	160.60 miles per hour
3,280 ft. elevation	220.55 miles per hour

This is air moving within itself; that is, not pressing against any fixed surface, such as a building, steel or other tall shaft or chimney. If wind moved with an absolute uniform velocity, it would impose a static load, but it is always more or less puffy, seen by observing stretched wires or ropes and trees, which surge in the wind.

The load imposed by wind pressure is, therefore, a "live load," which is usually figured as requiring twice the strength of that imposed by a "static load."

The variations of pressure in structures at various heights were investigated by S. P. Wing, the results being published in the *Engineering News-Record*, vol. 88, page 440. Mr. Wing derives the formula $P = (0.00126\ H + 1.16)\ Pg$, where P = wind pressure at given height, lb. sq.ft., Pg = ground pressure and H = height in feet.

TABLE IV—WIND PRESSURE AT VARIOUS HEIGHTS FROM S. P. WING'S FORMULA

Height In Feet	Ground Pressures Pg = 20	Pg = 30.7
100	25.72	39.48*
200	28.24	43.34
300	30.76	47.21
600	38.32	58.82
672	———	61.40*
1,000	48.40	74.29

* Comparing the figures marked with asterisks with those used for the design of the Tokio Wireless Shaft, it will be seen that they are about one-half of the Tokio Shaft figures.

Considering the maximum wind velocity for the vicinity of New York City as 110 miles per hour, different formulas give results as shown in Table V.

In an article on chimney design, Jacker gives the equation $E = K_e \frac{v^2}{g}$ which he calls "equation 1," in which g is 9.81 meters per second acceleration; K_e, unit weight of air, which equation is metric and gives for an actual velocity of 36 meters per second or 80 miles per hour, a result equal to 15.35 lb. per square foot.

When calculations of wind moment are made for chimneys, no factor of safety is considered; by doubling the wind pressure we are using a factor of safety of 2, which at the same time provides against the higher stresses to be expected at some time from the surging or hurricane conditions of the wind (tornadoes with their circular twisting motion have not been reckoned with). In the author's "Chimney Book" he gives 50 lb. per sq.ft. wind pressure as the highest to be considered, although at the same time reference is made to the St. Louis tornado of 1896, when a pressure of about 90 lb. per sq.ft. was reached, which is about double the result given by example (*c*), Table V.

Factors of Safety.

If this doubling of wind pressure is used in chimney design a more moderate factor of safety for the strength of materials may be used. The author would suggest a factor of safety of 3 or 4, and if careful supervision is given in designing and the construction work, very satisfactory and safe chimneys should result.

Concerning the highest wind in the vicinity of New York City, the *Paterson Press* (N. J.) of Saturday, Feb. 24, 1912, has this to say: "Probably few people have an adequate idea of how hard the wind blew early on Thursday morning, Feb. 22. It was the worst ever experienced in this part of the country, and probably has been seldom surpassed in North America. According to the New York Weather Bureau the anemometer showed a velocity of 96 miles an hour for the five minutes beginning 1:08 a.m. For one minute of this interval the velocity instrument recorded 110 miles an hour. The highest previous record in New York City was 83 miles an hour, one day in April, 1909.

The *New York Times*, Feb. 23, 1912, also says: "The highest wind record before the above date was April 7, 1909, when 83 miles per hour was reached. At 1:10 o'clock yesterday for just a single minute, the big wind outdid itself utterly, traveling at a rate of 110 miles per hour. Between 9:30 and 11 a.m. 71 miles per hour was the average, and 70 at noon."

TABLE V—PRESSURES DUE TO WIND VELOCITY OF 110 MILES PER HOUR FROM VARIOUS FORMULAS FOR FLAT SURFACES

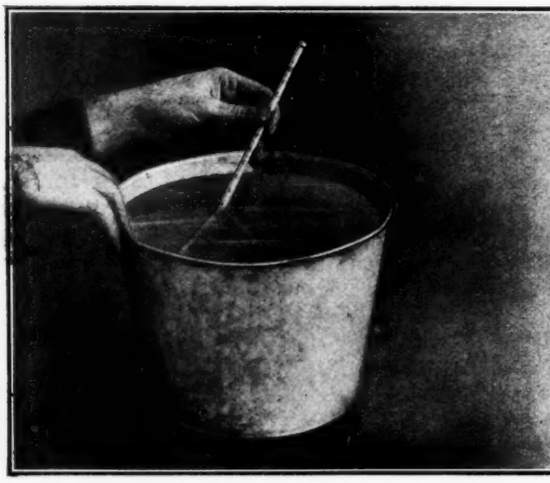
Marburg formula	$P = 0.0027\ V^2 = 32.67$ (a)
Burr and Falk formula	$P = 0.0054\ V^2 = 65.34$ (b)
This last for 32 deg. F. and barometric pressure of wind velocity.	
U.S.A. formula	$P = 0.004\ V^2 = 48.40$ (c)
U.S.A. formula	$P = 0.004\ Va^2 = 27.69$ (d)
Va is here the corrected value of wind velocity, deducing 30 per cent for error of Robinson's Anamometer.	
British formula	$P = 0.0031^2 = 36.3$ (e)

In Paterson, N. J., twenty miles away from New York City at about 10 a.m. the glass in three windows each, of two houses a mile apart, were blown in. These windows faced the south and singularly enough had passed through the 110 miles per hour wind in safety, but gave way under the 71 miles per hour wind from the northwest, which was very gusty in its nature. Another feature of this storm was the drop in temperature of 51 deg. F. at 1:45 a.m. to 22 deg. at 10 a.m.

The insulation resistance of the armature of a generator may be conveniently measured by the use of a voltmeter the internal resistance R of which is known. First, measure the voltage E of the circuit that is being used to make the test, then connect one terminal of the voltmeter to one side of the line, connect the other terminals of the line and voltmeter to the commutator and shaft, and this will give a value E'. The insulation resistance R' of the armature may be found by the formula, $R' = \frac{(E - E')R}{E'}$. The resistance of the field winding is found by the same formula; the reading is taken from one field terminal to the frame of the machine.

The correction of the hydrometer reading is based on the fact that the specific gravity of electrolyte changes one point (0.001 sp.gr.) for each 3 deg. F. above or below 70 deg. The correction is added to the hydrometer reading if the temperature of electrolyte is above 70 deg. and subtracted from it if below. For example, if the hydrometer reads 1.191 sp.gr. at 76 deg., the corrected reading is 1.193 sp.gr.; if at 64 deg. the corrected reading is 1.189 specific gravity.

It is a good plan to determine the operating condition of the non-return valve each time a boiler is cut out or allowed to become inactive for any length of time. Observe the steam gage, and if the pressure on the idle boiler falls below that of the other boilers, it is evidence that the valve is functioning properly. If the pressure remains the same, the valve should be examined at the earliest opportunity.



How to use Mercury-in-glass Thermometers

by

Wm. L. De Baufre*

THE mercury-in-glass thermometer is more widely used for temperature measurements than any other instrument available for that purpose. Temperatures may be measured with it to an accuracy of 0.002 to 0.003 deg. C.,[1] but great care must then be exercised to eliminate all errors as far as possible and to apply corrections for those errors that cannot be avoided. In power-plant and other engineering work it is rarely necessary to measure temperatures to this degree of accuracy, consequently the engineer does not need to bother with many errors that the scientist must consider in very exact temperature measurements. However, unless the engineer understands the errors to which a mercury thermometer is liable, he may use the instrument under conditions that greatly exaggerate those errors and thus render his measurements unreliable. This article will explain briefly the errors to which a mercury-in-glass thermometer is liable.

Effect of Exposed Stem

Thermometers are usually graduated for total immersion; that is, to read correctly when the whole mercury column as well as the bulb is exposed to the temperature it is desired to measure. In power plants thermometers are often placed in wells with the bulb and an inch or two only of the stem immersed, a large portion of the mercury column being exposed to a lower temperature. The reading is then low, but a correction for the exposed stem may be applied to obtain the correct reading as explained on page 320 of the Feb. 27 issue. From the curves in the article referred to, it is seen that the error due to an exposed stem may reach 30 to 40 deg. F. for stack temperatures, 15 to 30 deg. for superheated-steam temperatures, and 5 to 15 deg. for saturated-steam temperatures.

For permanent installations thermometers may be obtained graduated for partial immersion. This eliminates the necessity for exposed-stem corrections and is therefore very convenient for routine use. Thermometers graduated for total immersion are preferred for test purposes, however, since such thermometers can be used under any conditions of immersion and stem temperature and corrections applied therefor.

It would hardly seem necessary to caution against removing a thermometer from a well to read it, yet that has been done. At times it is necessary to measure the temperature of a tank of liquid by suspending a thermometer in it. If possible, the thermometer should be read without removing it from the liquid, raising it near the surface and tilting it so that the mercury column and graduations can be seen. If necessary to remove the thermometer entirely, a change of indication before reading may be prevented by tying rags or waste around the bulb and stem, but the reading should be taken quickly.

Broken Mercury Column

A mercury thermometer should never be used in a horizontal position if possible to avoid it, because the mercury column is likely to part. If the parting occurs within a horizontal well into which the thermometer projects, all the readings at the outer end of the mercury column will be too high. Also, it is difficult to keep mercury or oil around the bulb in a horizontal well. When necessary to insert a thermometer in a vertical pipe, the drilling and tapping should be inclined to the horizontal so that the well projects downward into the pipe. Special angle thermometers may be purchased for permanent installations. Even a thermometer used in a vertical position should be examined from time to time to see that a length of mercury has not become detached from the main column.

A broken column can generally be re-united by holding the thermometer in one hand and striking the wrist of that hand against the palm of the other hand. With very sensitive calorimeter thermometers having large thin-walled bulbs, even such gentle jarring might be sufficient to cause the mercury to break the bulb, so that great care must be exercised. If a thermometer has a large expansion chamber in the bore at the top of the stem, the bulb may be very slowly and carefully heated until the broken part and the tip of the unbroken column are driven up into the expansion chamber where they can unite. Overheating would burst the bulb. The column can also be reunited by cooling to the temperature of melting ice or lower; for if all the mercury is drawn down into the bulb, the gas bubble separating the two parts of the column can escape to the surface of the mercury, which it could not do in the capillary bore.

The space above the mercury column is filled with

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[1]While most mechanical-engineering work in this country is carried out with the Fahrenheit rather than the centigrade temperature scale, the latter is widely used for scientific work, and it is sometimes necessary to make use of centigrade thermometers in engineering work. Since the ice point is 32 deg. F. and 0 deg. C. and the boiling point 212 deg. F. and 100 deg. C., it is evident that each centigrade degree is equal to 1.8 Fahrenheit degrees. For changing from one to the other, use the following rules:

$$\text{Deg. F.} = 32 + 1.8 \times \text{Deg. C.}$$

$$\text{Deg. C.} = (\text{Deg. F.} - 32) \div 1.8$$

a neutral gas, nitrogen or carbon dioxide, to prevent boiling of the mercury at high temperatures. If boiling occurs, the mercury surface becoming indistinct, it is an indication that the filling with gas has not been properly done.

Even though the neutral gas is under sufficient pressure to prevent boiling, mercury vapor of a density corresponding to its temperature occupies the gas space. If the upper end of the thermometer tube is cooled by a draft of cold air, the mercury vapor will condense on the walls of the tube. To prevent condensation, it may be necessary in exceptional cases to provide a special heater for the exposed stem, but it is usually sufficient to protect the stem from drafts of cold air. By slightly withdrawing the thermometer from the hot fluid in which it is immersed, the mercury surface becomes as cool as the stem above, thus reducing vaporization.

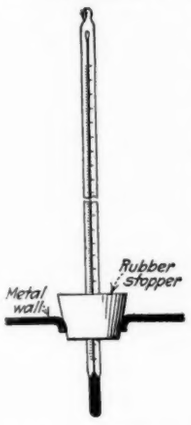


FIG. 1—THERMOMETER HELD BY RUBBER STOPPER

In some cheap thermometers the mercury will be found to cling to the sides of the bore, rendering the reading difficult and inaccurate. This is because the mercury or the bore was not thoroughly cleaned when the thermometer was made. It may also be due to oxidation of the mercury if some air was introduced when the tube was filled with a neutral gas.

At high temperatures the thin-walled bulb of a thermometer becomes soft and permanently yields to the high internal pressure of the neutral gas and mercury vapor. The safe limits are 850 deg. F. for normal glass and 950 deg. for borosilicate glass. Thermometers are sometimes graduated to temperatures 50 deg. higher than these values, but should be exposed to such temperatures for very short times only. If the thermometer is graduated for total immersion, it may indicate 25 to 50 deg. lower than the bulb temperature, as already explained. Even if the bulb does not burst when a thermometer is exposed to excessively high temperatures, the softened bulb may be enlarged by the internal pressure, thus producing a permanent error in its temperature indication. If necessary to use a mercury thermometer at very high temperatures, its indication at room temperature should be frequently checked to show whether any deformation of the bulb has occurred.

In very precise measurements it is necessary to take into account the difference in internal pressure due to the head of mercury above the bulb when the thermometer is horizontal or vertical. In ordinary engineering measurements this error is negligible.

Effect of External Pressure

In very precise temperature measurements the indications of the thermometer are corrected to standard atmospheric pressure. The numerical value of the correction is determined experimentally by immersing the thermometer in water in a closed glass tube and noting the change in its reading due to a measured variation in pressure. While the variations usually encountered in the atmospheric pressure produce an inappreciable effect in ordinary temperature measurements, the bulb of a thermometer should not be exposed to a fluid pressure much different from atmospheric without first determining the error thereby introduced. For example, a rise of about half a degree resulted from subjecting a thermometer having a range of —20 to 120 deg. F., to an external pressure of 25 lb. per sq.in. above that of the atmosphere. Care should also be taken that the bulb of a thermometer is not subjected to any mechanical pressure, such as being wedged in a thermometer well.

Elastic Hysteresis

Owing to "elastic hysteresis" the glass of a thermometer tends to retain its original form when the temperature is changed. This elastic hysteresis is expressed in terms of the depression of the ice point noted immediately after a given temperature reading. In very precise measurements it is necessary to note the ice point immediately after every temperature reading. The ice-point depression increases with the temperature measured, varying with the best thermometer glasses from less than 0.1 deg. C. for a reading of 100 deg. C. to 2 or 3 deg. C. for 300 deg. C. The depression gradually disappears with time. In engineering work it is impractical to note the ice point after every temperature reading. To avoid appreciable errors, low-temperature measurements should not be attempted with thermometers that have been recently exposed to high temperatures. It would be desirable to have the maximum temperature indication on low-temperature thermometers limited to 120 or 220 deg. F., and the minimum indication on high-temperature thermometers limited to 150 or 200 deg. F. The four ranges of —40 to 120, 20 to 220, 150 to 450 and 200 to 800 deg. F. have been found satisfactory for general engineering test work.

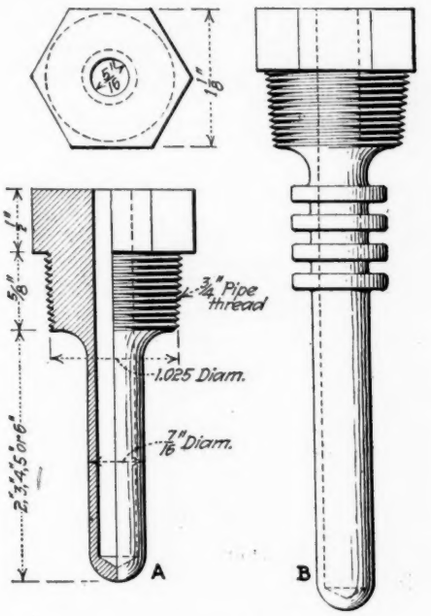


FIG. 2—THERMOMETER WELLS
A—Ordinary type for saturated steam.
B—Special type for gases and superheated steam.

Strains are produced in the glass bulb and stem during the process of manufacture, and heat treatment is

resorted to in order to relieve them. Unless the temperature attained during the heat treatment is sufficiently high, is maintained for a sufficient length of time and is reduced very gradually, some strains will persist and be present when the stem is graduated. These will be relieved in time—more quickly if the thermometer be used at high tmperatures—with a consequent decrease in the volume of the bulb and the cross-sectional area of the bore. The indications of the thermometer for all temperatures will rise 30 to 40 deg. C. or more. With proper heat treatment before graduation, the strains would have been entirely relieved. Errors due to gradual relief of strains in the glass may be detected by checking from time to time

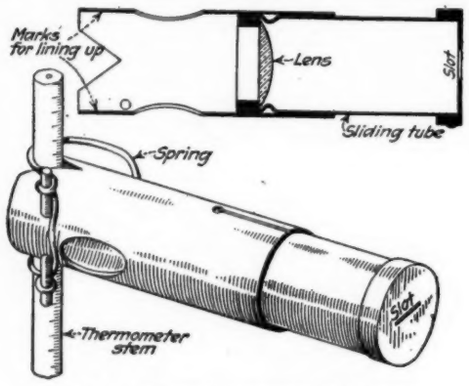


FIG. 3—THERMOMETER READING GLASS

the reading at room temperature, or preferably the ice point or steam point.

Frictional resistance between the mercury and the walls of the small bore tends to prevent the mercury column coming to rest in its proper position corresponding to its temperature. This effect is negligible in thermometers of the ordinary ranges and scales used in engineering work, and such thermometers should not be tapped for fear of breaking them. The indications of highly sensitive calorimeter thermometers, however, are appreciably affected, and it is desirable to eliminate errors due to friction by attaching a small electric buzzer to the stem and operating it by a push button just before reading. Also, it is preferable to take readings with a rising rather than a falling temperature since the irregularities are less in the former case.

Temperature Lag

When a thermometer is immersed in a warmer or cooler medium for the purpose of ascertaining the temperature of the latter, it does not immediately indicate this temperature, but exhibits a time lag in approaching it. If the temperature of the bath is changing at a uniform rate, there is a certain number of seconds between the time the bath attains any given temperature and the time when the thermometer indicates the same temperature, if the thermometer has been immersed for a long time. The numerical value of the lag may be experimentally determined, and a correction applied for the error produced thereby. Its value depends upon the form of the thermometer and the character and motion of the medium in which it is immersed. The lag is greatest in a dry gas and least in a condensing vapor. Where it is necessary to measure changing temperatures, the thermometer bulb should be exposed directly to the medium if possible, in order to eliminate the additional lag of the well and contained liquid.

Lag may be considered to a certain extent an advantage, in that the readings thereby fluctuate less from the mean temperature of a medium continually varying up and down. Thus, if the pressure of saturated steam supplied to a given apparatus is regulated according to the indications on a pressure gage, the mean of the temperature readings obtained from an adjacent mercury thermometer may be depended upon to represent more closely the average condition of the steam than the mean of the gage readings.

Effect of Conduction

Glass is a poor conductor of heat, so that if a thermometer be held in a rubber stopper, as shown in Fig. 1, the bulb will take up the temperature of the medium into which it projects and comparatively little heat will travel along the glass stem. If a shallow iron thermometer well with thick walls is used, a considerable quantity of heat will be conducted through the metal of the well to the fitting into which it is screwed; consequently, the immersed end of the well will assume, and the thermometer will indicate, a temperature between that of the medium and that of the fitting. In order to reduce to a negligible quantity the error due to conduction of heat along the thermometer well, it should have thin walls and be as deep as the location permits—three to six inches for ordinary engineering work. A cast-iron well that has been used for steam pressures up to 300 lb. gage, is shown at *A* in Fig. 2.

In measuring the temperature of saturated steam or any other condensing vapor, the error is a minimum with a given well because the vapor by condensing gives up heat with no fall of temperature. With superheated steam and other dry gases the heat conducted away can be supplied only by a drop in temperature of the gas in contact with the well. To minimize the drop in temperature, projecting fins are sometimes provided to bring a greater mass of gas into contact with the well. It is considered sufficient to provide only two or three collars near the head of the well, as shown at *B* in Fig. 2. By providing sufficient surface on these collars, practically all the heat conducted to the head of the well is withdrawn from the gas by the collars, thus permitting the lower part of the well to assume the full temperature of the gas with little radiation due to the small surface exposed, and to follow the variations in temperature with minimum lag due to the small amount of metal present.

Conduction of heat from the thermometer well to the fitting into which it is screwed, has also been minimized with moderate pressures by using a fiber bushing between a half-inch pipe thread on the well and a three-quarter-inch pipe thread in the fitting.

Radiation Causes Serious Errors

Heat is radiated in straight lines between any two bodies at different temperatures. A thermometer in a stream of hot fluid will take up heat from that fluid; but if it is surrounded by a relatively cool pipe, it will give up heat by radiation to the pipe. Consequently, the thermometer will indicate a temperature between that of the fluid and that of the pipe. The indication of a flue-gas thermometer is often low by reason of adjacent relatively cool walls and boiler surfaces, while

that of a thermometer in an air duct may be high by reason of near-by steam coils. This error can be reduced, and often practically eliminated, by a suitably disposed screen which will assume a temperature between that of the fluid and that of the near-by surface. The radiation to the screen is much less than it would be to the surface. However, the screen should not prevent free circulation of the fluid around the thermometer.

Fluids transmit heat mainly by convection, so that circulation past the thermometer is essential to accurate temperature measurements, either to supply the heat lost by conduction and radiation from the thermometer or to remove the heat supplied through these channels to the thermometer from surrounding bodies. To measure the temperature of a still fluid, a number of thermometers must be used, by reason of the large differences in temperature that may exist. For example, the temperature in an 8x16-ft. tank containing air at about room temperature was over 10 deg. F. warmer at the top than at the bottom. A fluid flowing in a pipe may preserve for great distances appreciable differences in temperature throughout the cross-section. Thus, in a test of a feed-water heater it was found necessary to introduce vanes to mix the outlet water thoroughly before consistent temperature readings could be obtained.

Pockets Should Be Avoided

Care should be taken that a thermometer is not located in a pocket out of the main line of flow where fluid of a higher or lower temperature than the average can collect. In this connection it is well to remember that water or other liquid will collect at the lowest point of a line conveying a gas, that air or other gas will collect at the highest point of a line conveying a liquid, that air of the same pressure and temperature as saturated steam has a higher density and will collect in the bottom of an apparatus containing condensing steam, and that water may flow along the bottom of a pipe containing superheated steam.

When a thermometer is placed in the stream of a very rapidly flowing fluid, heat is generated not only by friction, but by impact of the fluid against the bulb of the thermometer or the tube of the thermometer well. The kinetic energy of mass motion is then converted into heat energy. For this reason it is impossible to measure with a mercury thermometer the true temperature of a stream of air or of steam issuing from a nozzle under high pressure.

Parallax is the error resulting from viewing the top of the mercury column in a direction not at right angles to the thermometer stem, since the scale marks are not in the same plane as the mercury column. If viewed from above the top of the column, the reading will be too high, and if viewed from below the reading will be too low. The simplest means of avoiding parallax is to note the reflections from the mercury of the graduation marks on the glass stem. When the reflections near the top of the column disappear behind the corresponding division lines, the eye is on the proper level for reading.

Methods of Preventing Parallax

Reading glasses are available for avoiding parallax and, at the same time, for magnifying the indication. A magnifying glass alone is not sufficient, as parallax errors will be magnified unless the line of sight passes through the center of the lens and at right angles to the thermometer stem. A simple reading glass of satisfactory form is shown in Fig. 3. The marks on each side should be adjusted to the level of the top of the mercury column. The narrow slot at the other end then assures the line of sight being perpendicular to the stem and passing through the center of the lens. The latter magnifies the scale about five times.

When using a reading glass as already described, however, the eye must be close to the thermometer. It is often more convenient to read the thermometer with a telescope from a distance. Parallax is avoided by setting the thermometer at right angles to the line of sight from the telescope. In very precise measurements two sets of readings may be taken—one set with the scale marks in front of the mercury column and another set with the thermometer turned to bring the scale marks in back of the column.

By practice an observer will learn to estimate very closely the fraction of a division at which the top of the mercury column stands. Errors in estimation are mainly due to dividing mentally the space between the division marks rather than the distance between the centers of the marks. Division marks have an appreciable width, often as much as one-tenth of the distance between their centers. Micrometer microscopes are made especially for measuring the exact position of the mercury surface in thermometers, but their use is not recommended since a greater number of observations may be taken in a given time by estimation with nearly as great accuracy.

Carbon-Monoxide Poisoning

It has been stated by various medical authorities that headache may be taken as an indication of carbon monoxide poisoning. Investigation of this condition indicates that some people do not develop headache even when exposed to low concentrations for several hours, and yet they may exhibit severe and even disastrous symptoms otherwise. Again, if the concentration of carbon monoxide in the air is sufficiently high, a headache many not develop for some time after returning to fresh air, or the subject may become unconscious almost without warning, resulting perhaps in death.

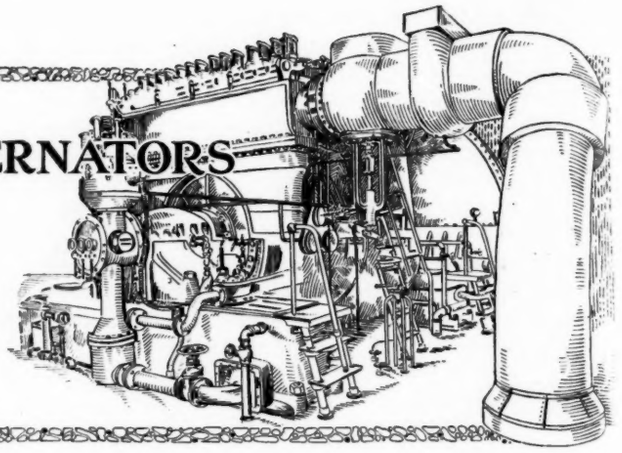
In other words, while the symptom of headache is the most common indication of carbon-monoxide poisoning, the time of its appearance, or whether it appears at all, will depend upon the concentration of carbon monoxide in the air and upon individual peculiarities of the person affected.

The statement that there is apparently no danger from carbon-monoxide poisoning if headache is taken as a warning and the patient immediately returns to fresh air, should therefore not be taken too literally, as it may not hold in all cases. In the opinion of authorities there might be possibility of an accident or even disastrous results if headache alone were taken as the primary symptom. Persistent yawning, sleepiness, dizziness and lassitude are frequent symptoms. Many subjects have a feeling that the skin is stretched tightly across the forehead. There is no symptom specifically characteristic of carbon-monoxide poisoning, but when any of the foregoing symptoms occur, it is an indication that there is something abnormal either in the condition of the man himself or in the air he is breathing. If not sure of the purity of the air, the man should go to a point where it is unquestioned.—*Lubrication.*

STARTING TURBO-ALTERNATORS *and putting* THEM IN SERVICE

by

Guy M. Mankin



PUTTING a large turbine in service cannot be done in a moment. Unlike the smaller units the modern large turbine, because of its great size, cannot be started in a hurry. The development of the turbine has increased and complicated the auxiliaries involved; and each increase in size of the unit is reflected in a practical way in the interval that must elapse between a signal from the switchboard for an additional unit and the actual loading of that unit in order to permit the consummation of the various progressive steps involved in the intricate process of starting. The manner of performing these steps is made as nearly routine as possible, and routine by constant repetition becomes habit. Thus the practice becomes automatic so long as everyone functions co-ordinately.

Communication Between Operators

For communication between switchboard and turbine operators the combination of visible indicators with audible signals as check is in use generally in power plants, each signal either way being repeated back to insure correct receipt. The switchboard operator's request for the starting of a unit may be routine, due to normal increase in load, or emergency, due to loss of a unit within his own plant or to sudden overload due to abnormal increase or loss of capacity outside of his plant. A routine request for a unit is made by the switchboard operator signaling "Slow" on the unit desired an hour or more in advance of the time it is wanted on the line. An emergency request would be indicated by the signals "Emergency, No. —— Unit."

On receipt of the "Slow" signal the turbine operator first starts up the condenser circulating pumps. He inspects the condenser itself for open doors and to see that the pump discharge is closed and the tail vent pipe on the condenser is open. Water is then turned on the pump seals until a slight excess is obtained as indicated by a small stream running out. The circulating pump is then primed with either a steam or an air ejector by opening the ejector valve until the pump is full of water. On a turbine-driven pump the reduction gear would be examined for proper quantity of oil, since the expansion of the oil on heating creates pressure, and if the gear case be too full, some of it will be forced out as leakage.

After the drain and exhaust valves have been opened on the circulating pump's turbine and the overload valve closed, the throttle valve is opened and the set rotated at a slow speed. After the drains have been closed again, the bearings are checked to see that the oil rings are working properly. The unit is brought to speed slowly and the throttle valve opened wide, allowing the governor to take control. The governor is always tested to determine that it slows the unit when pushed into the closed position.

The discharge valve is opened when the pressure of the pump discharge reaches 8 or 10 lb. These valves usually are motor-driven, controlled from convenient points on the turbine floor. When water flows out of the condenser vent tail pipe, it shows that the water-boxes are full and that water is flowing over and down the tail pipe. The vent valve may then be closed. The air pump may be started at the same time as the circulating pump and the same routine observed with it. On pumps of the "air and water piston" type, such as the Le Blanc, the hurling water should be throttled down so as to give the suction that experience has shown results in the best vacuum for that unit. When the pump has reached normal speed, the suction valve to the condenser steam space is opened slowly.

If the water in the condenser hotwell is out of sight above the gauge-glass level, the condensate pump must be started and the hotwell water brought back to the proper level before the turbine throttle valve is opened. Condensate pumps are fitted with vacuum equalizing lines which conect the pump volute with the condenser to allow the water to fall to the pump by gravity rather than force the pump to work against the condenser vacuum. The valves in this line are opened as soon as the pump has come to speed.

Time Required for Starting Auxiliaries

The operations so far should have consumed about 15 min. When the condenser vacuum has reached 6 or 8 in. of mercury, the warming of the main turbine is begun. All drains are opened and the auxiliary oil pump for the bearings and governor started. Cooling water is turned on the bearings and on the oil cooler. The high-pressure seal has steam turned on it and the low-pressure one water, if water-sealed, so that any leakage into the turbine will be either steam or water and the vacuum not affected. All gages are checked to determine that proper oil and water pressures are being maintained at the various points.

The turbine is warmed while slowly rotating to prevent strains due to unequal steam distribution. Owing to starting friction more steam is required to turn over the unit than to run it. For this reason the throttle valve is first opened wide enough to clear the bypass, and then, when the unit has started to rotate, is closed

enough to let the bypass alone handle the steam to rotate it. The unit is kept at this slow speed until thoroughly warmed up, one minute per 1,000 kw. rated capacity—30 minutes for a 30,000-kw. unit—being allowed. When the warming process has begun, the turbine operator communicates this fact to the switchboard operator by the signal "Slow, No. —— Unit."

After allowing the proper interval for warming, the switchboard operator signals "Speed" on the unit. The throttle is then gradually opened to bring the unit to speed, allowing another minute per 1,000-kw. capacity. As the turbine speed increases, the shaft-driven oil pump in the governor casing of the turbine reaches a speed where it can maintain the proper oil pressure, and the auxiliary oil pump is automatically shut off. The steam valves to the auxiliary oil pump are left open, but it is under governor control and does not go on the line unless the pressure of the main oil pump drops below the pressure required. The seals must be watched and adjustments made on both steam and water. These adjustments must be delicately made to prevent temperature changes and the blowing of water from the seals by excessive steam pressure.

While the machine is coming up to speed, care must be taken to limit the first-stage pressure to zero pounds gage to prevent too rapid acceleration of the machine. When running speed has been reached, as indicated by the speed indicator on the gage board and by the action of the governor in partly closing the admission valves, further acceleration will be prevented by the governor, and the throttle valve may be opened wide. The throttle should now be tripped and reset by hand, to make certain that it is in proper working order and capable of being tripped by the overspeed tripping device. In addition to this test each unit is tested once a week to determine the speed at which the emergency operates, and make any necessary adjustments to the setting. A final inspection of the bearings and seals is made, then the turbine operator signals "Load" on the unit to the switchboard man, for a 30,000-kw. unit under ordinary conditions the time thus far consumed would have been an hour and a quarter.

While the unit is coming up to speed, the switchboard operator energizes the alternator field, with all rheostat resistance cut in. Brushes, slip rings and exciter are inspected, and the pump of the alternator air washer started. On receipt of the "Load" signal the operator raises the machine voltage to correspond with that of the bus, and after checking his instruments to determine that field current, voltage on each phase, ground lamps, etc., are normal, he proceeds to synchronize. The first and rough adjustments to bring the machine into phase with the bus are made on the phase lamps, after which the synchroscope is plugged in and checked against the lamps before being used to synchronize the unit. As was the case in warming the unit, the period of one minute per 1,000-kw. rated capacity is observed in loading in.

The switchboard operator's responsibility in putting a unit on the line amounts practically to a check of the whole starting-up process. The proper study of his instruments while bringing the machine to speed and voltage, synchronizing it against the bus and loading it, will inevitably betray anything improper in its behavior. Synchronizing a large unit is in itself quite a responsibility. Classed as a simple act by many, it really amounts to an art in precision and a science in judgment. All instruments must be checked against each other, and in no case should the generator switch be closed before the synchronoscope has made at least one complete revolution in a perfectly natural manner. A synchronoscope pointer traveling over the scale in erratic jumps might portend an alternator 80 per cent underexcited.

In taking a unit off the bus the switchboard operator first signals "Stand-by" to warn the turbine operator that he is about to work off the remaining load on the unit and take it off the bus. The turbine operator watches the sealing system and tests out the action of the auxiliary oil pump by starting it by hand. When the "Stop" signal is received from the switchboard, the throttle valve is slowly closed and the auxiliary oil pump checked to insure maintenance of the proper oil pressure. The steam and water seals are shut off and the air and condensate pumps stopped. The circulating pump is shut down after the unit has stopped. The oil and water supply to the bearings and the auxiliary oil pump are then shut off. The vacuum valve is opened and an inspection of the unit made to see that the admission valves have been opened by the governor.

THE practice followed in putting large turbines into service is one that varies considerably in different stations, but in most all cases a considerable period is allowed for warming-up and loading the machine. This article represents the practice in one large central station and no doubt the time, one and three-quarter hours, required to start a 30,000-kw. unit from a cold standstill and get it fully loaded, may seem to be long to some operating engineers. The importance of starting these large units properly would be hard to overemphasize, since more of them are going into service all the time. Many operators undoubtedly would like to know how the custom in other plants differs from the one here described, and "Power" will be pleased to have for publication discussions from other engineers as to their practice in starting turbines.

The unit is not taken off the bus until after the "Stop" signal has been given and a steady dropping of the load on it as indicated by the wattmeter shows that the throttle valve has been closed. All oil switches are then opened, the field current reduced to a minimum and the field-breaker opened. Should it be desired to bring the unit to a standstill quickly after taking it off the bus, the field is kept energized and the current in it increased by cutting out rheostat resistance.

Emergency situations requiring an immediate addition to the generating capacity on the bus are anticipated in central stations by having at some part of the system units in "first reserve," these units having their turbines kept warm and all the auxiliaries on them turning over during the period in which they are held in reserve. Little time can be cut from the routine in the case of the auxiliaries, except by employing extra men in some parts of the starting-up process. Some of the customary repeated inspections of the seals, bearings and oil cooler of the main unit may be dispensed with once a thorough initial inspection has been made and these accessories have started to function properly.

The principal saving in time is made in dispensing with much of the warming-up procedure, instead bringing the unit slowly to speed, allowing little more than one minute per 1,000-kw. capacity. Thus the total time to bring a 30,000-kw. unit to speed from a cold standstill may be cut to about 40 minutes. A unit in reserve could be made available in a much shorter time. In one company the general rule for emergency starting of the larger units is one hour for a cold unit and half that time for one in reserve.

A unit that has tripped out and shut its throttle through the overspeed trip will have to be inspected before being started again. When the trouble has been corrected, the unit may be put back on the line in short order if it is still turning. Otherwise it would have to be brought to speed slowly. Instances where a unit may be put right back on the line after tripping in this way, are the cases where trouble on its field excitation causes it to drop out of step with the electrical system and run away and trip, or where the overspeed trip itself operates without proper cause.

No unit is ever shut down by the turbine operator without first notifying the switchboard by the signals "Stand-by" and later "Stop," nor does the switchboard man take a unit off the bus without first notifying the turbine operator in the same way. In all these operations routine procedure is followed as closely as conditions permit.

Comparative Fuel Costs of Coal and Oil

By E. T. McCarthy

With the increasing use of crude, fuel oil and distillates in place of coal, everyone interested in the purchase or sale of fuels and fuel-burning devices, has frequent occasion to calculate the relative costs. The diagram on the opposite page has been devised to facilitate such calculations.

It has been the aim of the writer to reduce to a minimum the number of scales and groups of lines and still take into account the necessary factors. To this end the vertical scale along the left margin has been made to serve for the cost of coal, coke, lignite, etc., in dollars per ton, and also for the cost of liquid fuel in cents per gallon. A supplementary scale may be plotted to show oil costs in dollars per barrel.

These costs should include not only the cost of fuel delivered into the bunkers or tanks, but also the cost per ton or per gallon for labor of handling and firing; of power for conveying, pumping, crushing, atomizing, operating stokers, etc.; of insurance, depreciation, repairs and everything that may be charged to either fuel in order that a fair comparison may be made. Such factors as convenience, flexibility, availability, cleanliness, etc., are important but cannot be represented on a chart.

The horizontal efficiency scale takes into account the over-all thermal efficiency developed by the equipment in which the fuel is burned. The Baumé gravity scales in the upper and lower right corners have been carried to 45 deg. Baumé to include kerosene. Lighter fuels hardly come into competition with coal or the heavier oils. The corresponding specific gravities and weights per gallon have been inserted. The inclined solid lines, representing the B.t.u. per pound of solid or liquid fuel, converge at the zero of the cost and efficiency scales. The inclined dotted lines show the B.t.u. per gallon of oil.

The chart may be used for the solution of several kinds of problems, as is indicated in the following examples:

Example 1—An oil contains 18,500 B.t.u. per pound and the efficiency developed is 78 per cent; find the B.t.u. realized per pound.

Locate the intersection of the vertical line from 78 per cent efficiency, with the diagonal line marked 18,500 B.t.u., and from the intersection proceed horizontally to the right margin. Answer—14,400 B.t.u.

Example 2—A certain coal contains 12,500 B.t.u. per pound, and the over-all efficiency developed is 72 per cent; find the effective B.t.u. per pound.

Proceed as before, by finding the intersection of the vertical line from 72 per cent efficiency with the 12,500 B.t.u. diagonal line, thence horizontally to the margin. Answer—9,000 B.t.u.

Example 3—An oil of 18,000 B.t.u. per pound and 25 deg. Baumé gravity, burning at 75 per cent efficiency, costs 6 cents per gallon including incidental charges. Coal containing 12,000 B.t.u. per pound burns at an efficiency of 70 per cent under the same boiler. Find the equivalent cost for coal.

Find the intersection of the vertical from 75 per cent efficiency with the diagonal of 18,000 B.t.u., thence proceed horizontally to the 25-deg. Baumé line, and from here diagonally downward toward the converging point to the horizontal through 6 cents per gallon. Mark this point. Then find the intersection of the vertical line from 70 per cent efficiency with the diagonal of 12,000 B.t.u., thence horizontally to the left margin and diagonally upward along the B.t.u. lines to a point vertically above the point just marked for oil. It will be seen that the point so found is opposite $9.90 per ton for coal. In other words, coal must have a total cost of approximately $9.90 per ton to be equivalent to oil having a total cost of 6 cents per gallon. The arithmetical solution is:

$$\frac{0.70 \times 12{,}000 \times 2{,}000}{0.75 \times 18{,}000 \times 7.53} \times 0.06 = \$9.91$$

Example 4—Another lighter oil contains 18,500 B.t.u., 30 deg. Baumé gravity, efficiency 78 per cent; what is the equivalent cost as compared with the oil of example 3?

Proceed as for the oil in example 3. Find the intersection of the vertical line representing 78 per cent efficiency with the 18,500-B.t.u. diagonal line; follow horizontally to the 30 deg. Baumé line and then down diagonally as before to a line passing vertically through the point marked on the 6 cents per gallon line for the other oil. The equivalent cost of the lighter oil is 6.2 cents per gallon.

Example 5—As heat values are expressed in B.t.u. per unit of weight while oil is bought by volume, it is interesting to compare heat contents per gallon. A sample of oil of 20 deg. Baumé gravity contains 18,000 B.t.u. per pound; find the B.t.u. per gallon.

Find the intersection of the vertical from 20 deg. Baumé with the diagonal of 18,000 B.t.u. per pound. This intersection lies on the dotted line for 140,000 B.t.u. per gallon.

In the same way the oils of examples 3 and 4 may be found to contain approximately 136,000 B.t.u. and 135,000 B.t.u. per gallon, respectively.

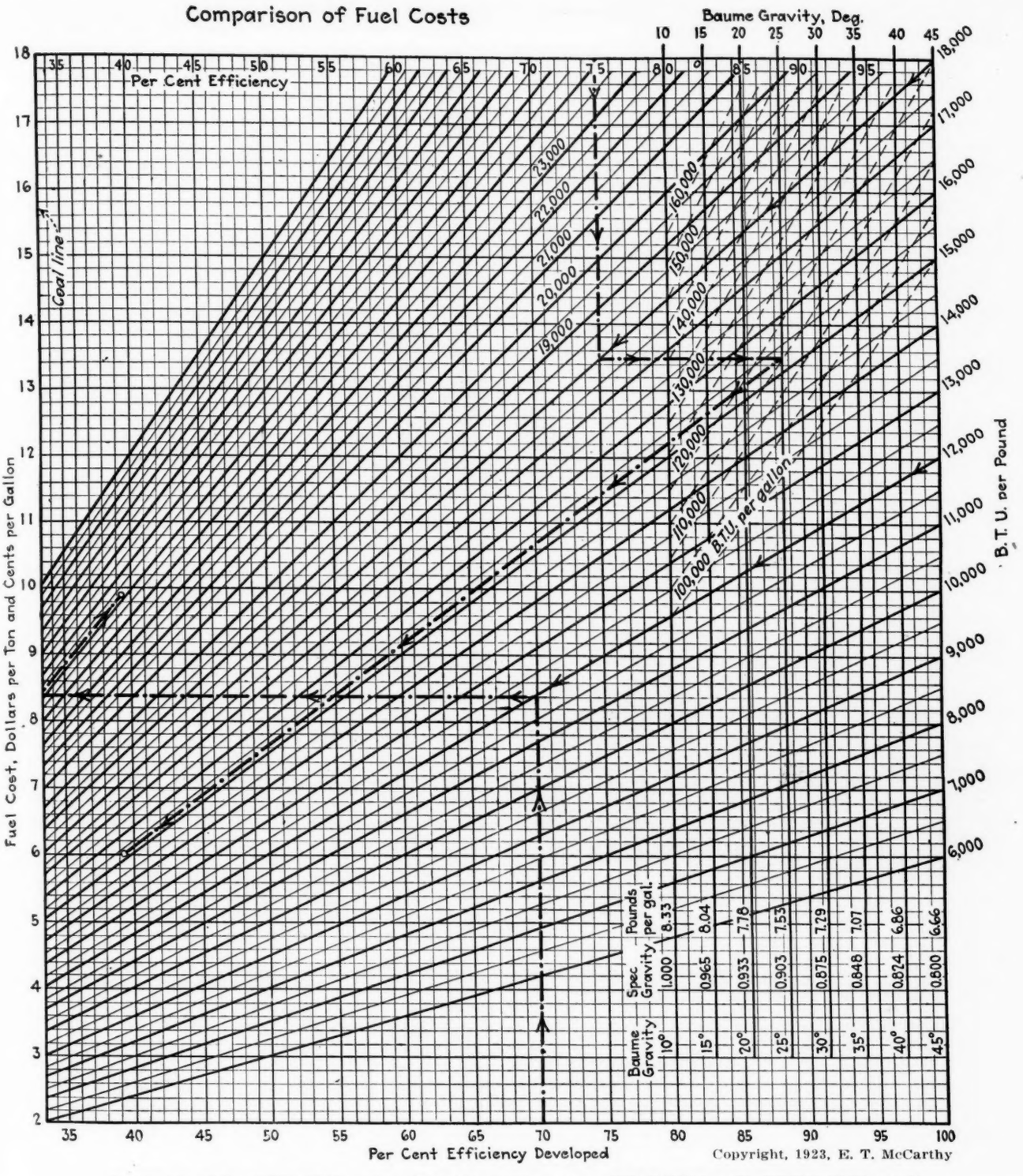


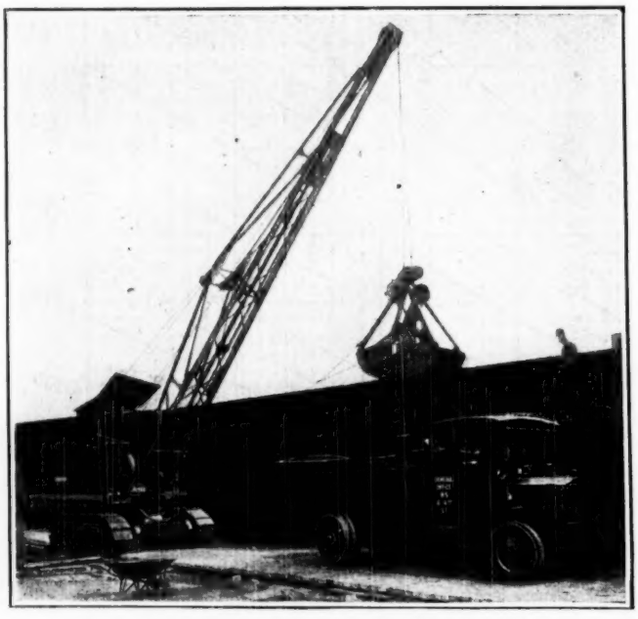
DIAGRAM FOR COMPARING THE COST OF FUELS ON A HEAT-UNIT AND EFFICIENCY BASIS AND FOR WORKING SPECIAL PROBLEMS WITH COAL AND OIL

The scale at the left is for the cost of solid fuels in dollars per ton of 2,000 lb. and of fuel oils in cents per gallon. The scales running across the top and bottom of the diagram are for the percentage of efficiency with which the fuel is burned. Gravities (expressed as degrees Baumé, specific gravity or pounds per gallon) are represented by the heavy vertical lines at the right. The inclined solid lines are B.t.u. per pound and the inclined dotted lines B.t.u. per gallon. Various types of problems are solved as follows: A—Given B.t.u. per pound and efficiency, to find B.t.u. realized per pound. Solution: Drop vertically from efficiency to B.t.u. contained; then move horizontally to right edge and read B.t.u. realized. B—Given B.t.u. per pound, gravity, efficiency and cents per gallon for oil and also B.t.u. per pound and efficiency for coal, to find equivalent coal cost in dollars per ton. Solution: Proceed as illustrated by heavy dot-and-dash lines, noting that the "oil line" starts at the top and the "coal line" at the bottom and that the two end points are in the same vertical line. C—To compare two oils, construct two lines like the dot-and-dash "oil line" of B. Similarly, to compare two coals construct two lines like the dot-and-dash "coal line" of B. In either case the two dot-and-dash lines must end in the same vertical line. D—Given the B.t.u. per pound and the gravity, to find the B.t.u. per gallon. Solution: Find the intersection of the vertical line for gravity and the solid slanting line for B.t.u. per pound. This intersection lies on the dotted line for B.t.u. per gallon. These problems are illustrated in the text.

Corduroy Crane

To meet the demand for a portable crane that could be operated any place on the premises of an industrial plant without runways or tracks, the Pawling & Harnischfeger Co., of Milwaukee, has brought out the so-called Corduroy crane shown in the illustration. Briefly, it consists of a long boom, cable drums and the control mechanism mounted on full-corduroy or half-corduroy traction according to the size of the machine. It may be driven with an internal-combustion engine or an electric motor and is operated by one man. The upper part of the machine swings in a complete circle, and the hoisting and swinging motion can be performed simultaneously.

The crane has been adapted for a large variety of uses. For industrial plants it is ordinarily used with a crane hook, electric magnet or clamshell bucket, which



CORDUROY PORTABLE CRANE

can be used interchangeably to handle practically any material. The crane is also used with a shovel boom or can be used with a dragline bucket or skimmer scoop for light grading.

It is made in three standard sizes, the smallest of which has a lifting capacity of 12,500 lb. at a 10-ft. radius and will handle a ½-cu.yd. clamshell bucket at at 30-ft. radium. The middle-sized machine has a lifting capacity of 19,000 lb. at a 10-ft. radius and will handle a ¾-cu.yd. bucket at a 30-ft. radius or a ½-cu.yd. bucket at a radius of 38 ft. In the largest standard size the lifting capacity at the 10-ft. radius is 35,000 lb. This crane will handle a 1¼-cu.yd. bucket at 35-ft. radius, a 1-cu.yd. bucket at 40-ft. radius and a ¾-cu.yd. bucket at 50-ft. radius. In the three sizes the length of boom ranges from 30 to 50 ft. and the lifting capacity naturally varies with the radius of action.

In plants where the drains from the different auxiliaries and machines lead to a common sump, considerable oil can often be reclaimed by skimming the surface of the water and passing it through a filter. Several barrels a year can often be reclaimed in this way.

The Coal Goes Up the Stack

The law of conservation of matter applies in the boiler plant exactly as in the chemical laboratory. Every pound of water, coal or air that goes into the boiler or furnace must, in the long run, be balanced by a pound going out. Of course the material going out may be chemically or physically changed, but its total weight cannot change.

This should be kept in mind when approaching the question of CO_2. All the air and coal supplied to a boiler must ultimately leave it in some form or other. The air must pass up the chimney, as must all the coal except that small part that falls through the grate. Assume—as is approximately true—that all the coal excepting the ash (say 10 per cent) goes up the stack with the air. Then out of each pound of coal fired there must be 0.9 lb. of coal going up the chimney in the combustion products. If 15 lb. of air is supplied for each pound of coal, the combustion products per pound of coal must weigh 15.9 lb. Now a pound of coal of a given composition produces a definite constant *weight* of carbon dioxide. It is possible, however, to change the *percentage* of CO_2 by simply increasing the total weight of flue gases per pound of coal. For example, in the case just discussed, if the air supplied per pound of coal is increased to 30 lb., the total weight of flue gases per pound of coal will be 30.9 lb., or practically double what it was before. The same weight of carbon dioxide will be a smaller percentage of the total, in fact, half of the original percentage.

This argument can be turned around. For example, if the CO_2 drops from 12 per cent to 6 per cent, it shows that the total flue gases per pound of coal have been doubled. Since the chimney is "nothing but a hot-air heating system for heating the sky," twice as much flue gas blown away at the same temperature means doubling the flue loss. Therefore, assuming a constant flue temperature, cutting the CO_2 in half doubles the flue loss.

Manufacturing ice with distilled water, owing to its lack of economy, has now gone almost entirely out of use, having been replaced by the raw-water system. The public demands clean ice. By clean ice is meant not necessarily pure or sanitary ice, but ice that looks clean and is free from any visible dirt, as well as being sanitary. There are three main reasons why water, although sanitary, may produce dirty ice. These are: (1) Presence of vegetable matter in colloidal solution. This type of water is corrosive and will carry rust into the core of the can ice, making the center yellow. (2) Lime and magnesia salts will precipitate in freezing and make a cloudy ice. (3) The presence of sodium salts causes an opaque ice mantle, though the bulk of the ice cake is clear. In the raw-water system, all impurities collect in the core from which it is pumped out and replaced by fresh water. There is a small thermal loss in the removal of the core but it may be avoided by pumping the cold core water over the condenser coils.

The best regulation of draft and of thickness of fuel bed is that which makes the hottest fire. Insufficient air supply causes incomplete combustion, and excess air supply causes too rapid dilution of the volatile gases; both these tend to cool the furnace. The hottest fire that can be obtained is one in which the air is enough in excess to insure perfect combustion and no more.

EDITORIALS

F. R. LOW, EDITOR

Efficiency in Coal Mining

THERE is evidence that the Fact-Finding Coal Commission is giving careful consideration to the problem of efficiency in coal mining. This is encouraging news to the coal users of the country, for one of the large factors in high costs undoubtedly has been inefficiencies in mining practice. One of the most conspicuous causes of inefficiency has been the irregularity of operation due to shortage of cars at the mine. But a partial remedy for this situation is easily available to the mine operator if he will but use it. This remedy lies in a small capacity for storage at the mine.

At present it is a common practice for miners to decline to go to work in the morning simply because the day's supply of cars has not arrived and they believe that after a very short effort they will be compelled to interrupt their work, since there will be no place to put the coal that would be produced after the first hour or two of mining. This results in a failure to operate the mine up to the capacity of the cars that actually are available later in the day. As a consequence the miner loses his day's work, the operator loses his profit, the cars stand idle unnecessarily for almost twenty-four hours, and the cost of coal goes up correspondingly.

If such mines were equipped with storage capacity equal to a single day's output, there would be no such difficulties. The coal could be brought to the surface, prepared for shipment and placed in such bunkers pending the arrival of the cars. Immediately after the cars were put on a siding, they could be promptly loaded and would be ready to start in a few hours instead of waiting to be filled on the next working day. It may be that such practice would not be possible in every mine, but certainly it could be applied in many locations and with profit to everyone concerned. It is encouraging to know that the Commission is investigating this matter.

Another cause of inefficiency in mining has been the low percentage of the coal which is mined out. In this country frequently forty to fifty per cent of the coal is never removed from the mine. On the average this waste is estimated to be from thirty to thirty-five per cent of the coal that is available. And, naturally, the ultimate user of coal pays for this waste just as truly as he pays for the coal in the car pushed onto his siding. It is pointed out that in European countries the mining waste is only about half as great as in this country. Naturally, the Coal Commission is seeking to know why there should be so great a discrepancy.

A third factor in high mining cost results from the operation of mines a single eight-hour shift each day. A large percentage of the metal mines in this country and practically all types of mines abroad are operating two or three shifts a day whenever possible. In the United States the general coal-mine practice is a single eight-hour shift. The cost for capital charges, management and all overhead expense is the same whether work goes on eight hours or twenty-four hours a day. It is almost as expensive to keep a mine properly ventilated and adequately pumped out for a single shift as for three. The Coal Commission naturally inquires, therefore, why it is not reasonable to extend the working hours in the coal industry materially and make more general use of two and three shifts per day.

These questions are only a few of the difficult problems that confront the Commission. It is too much to expect of that body that it should solve all such questions, but definite recognition of the problem and even partial solution will be worth while.

More Efficient Use of Water Power

NEW ENGLAND has a higher percentage of its water powers developed than any other part of this country. According to the 1920 report of the N. E. L. A. Committee on Water-Power Development, over seventy-seven per cent has been utilized. Taking these figures at their face value, it would appear that little additional water-power development might be expected in this district. But when the manner in which many of these power sites have been developed is considered, it becomes apparent that there are large possibilities for redevelopment of many of them, as shown by the leading article in this issue, "Redevelopment of One of New England's Oldest Water Powers," that of Amoskeag Falls at Manchester, New Hampshire.

Largely on account of the extensive water powers within comparatively easy reach of the seacoast, New England became one of the first great industrial centers of this country. As the industries increased, water-power development, such as it was, grew to meet the needs for power. Since the power requirements of each mill were in general small, the individual power unit was of small capacity. Although fifty wheels of an average capacity of about three-hundred horsepower were installed at Amoskeag Falls, this does not represent the worst conditions that have arisen out of the promiscuous development of water power, without a co-ordinated scheme for a complete utilization of the total power. In fact Amoskeag is one of the most efficient examples, for, unlike most of the water-power sites in New England, it has been under the control of one company from its earliest development. This made possible the following out of a comprehensive plan of utilizing the power which is not found in many of the other water-power developments. Even with this opportunity of making the development by the most efficient methods available in the early periods, it has been possible to redevelop this water-power site so that it will eventually produce one-hundred per cent more power from the water. The way that some of the other sites have been developed make possible obtaining from two- to three-hundred per cent more power from the water than at present if the most efficient methods are used.

Unfortunately, not all water powers in industrial cen-

ters are as easily redeveloped as those at Amoskeag. There the manufacturing plants are located below the falls, while at other sites they are grouped around the falls in such a way as to make redevelopment much more difficult, especially where water is required for process work or for condensation purposes in steam plants. Furthermore, these water rights are owned by a number of interests, which also further complicates the problem. However, this difficulty must be solved if New England is to provide an adequate power supply for those industries that have so long existed within her borders. The increasing price of fuel and the difficulties of obtaining it make the most efficient use of available water power of ever-increasing importance. Although the methods adopted at Amoskeag Falls cannot be used in every case, as each location has characteristics peculiar to itself, nevertheless what has been accomplished there teaches an impressive lesson in how inefficiently some of our water powers are being used and what may be done to improve the situation.

Facts as a Basis for Selecting Equipment

A PRACTICAL problem of frequent occurrence is that of deciding on the most suitable type and size of prime movers for an isolated plant where there is a marked variation in the heating and process-steam load. In most northern plants this load is higher in winter than in summer. Moreover, it varies not only from season to season, but also from day to day and from hour to hour. On top of this is a continuous change in the power load. A strictly scientific comparison among several proposed methods of furnishing power and heat for such a plant can, therefore, be made only where continuous records of the heat and power loads are available for the whole of some typical year.

With such records, together with guaranteed-performance curves for the various proposed installations, one can mentally carry each of the installations right through the whole of the typical year, estimating the coal consumption hour by hour for each individual hourly combination of heat load and electrical load. If the necessary hourly records are available, the labor of such extended computation will be repaid many times over.

If the continuous records are not now available because of the lack of recording instruments, it should pay to install the necessary instruments at once in order to get as extensive records as possible before the final decision is made. Granting reasonable intelligence in interpreting facts, the more facts and the fewer guesses an engineer has to work with, the greater are his chances of making a wise decision.

Even where time to make an hour-by-hour study of a whole year's operation is lacking, it is still important that the computation be based on hourly rather than daily totals or averages. It has been aptly remarked that a man might drown in a river whose *average* depth was two feet. The average power load for a given day might correspond nicely with the average heat load, yet an hourly investigation would probably show certain hours when the heat load far exceeded the power load, with a resulting heavy demand for live steam, and others when the opposite condition prevailed. In such a case the actual coal consumption would greatly exceed that calculated on the basis that the average loads were constant loads.

To take reasonable account of hourly and seasonal variations, as well as the disturbing effect of the week end, the year might be divided into thirteen periods of four weeks each, and the coal consumption estimated hour by hour for the first week of each period. The total thus found, multiplied by four, should give a very fair estimate of the yearly coal consumption. After the coal consumption for each installation had been closely estimated in this way, there could be added the other operating costs based—so far as possible—on guarantees, and capital charges based on quoted prices. If, in addition, a fair value were assigned to differences in reliability, convenience and other intangible factors, there would be a really scientific basis for an intelligent choice.

Reducing the Blowdown Loss

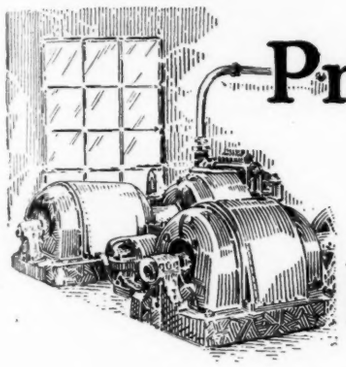
IT COSTS money to blow down a boiler. With a steam pressure of one hundred and fifty pounds gage the temperature of the boiler water is 366 deg., so each pound contains about 300 B.t.u. measured above an average make-up temperature. Even in a non-condensing plant with an excess of exhaust steam for feed heating the blowdown must be charged with the heat needed to raise the water from 212 deg. to boiler temperature. With a boiler efficiency of sixty per cent and 13,000-B.t.u. coal, this means a loss of about two hundred pounds of coal for every one thousand pounds of blowdown.

It is self-evident that haphazard blowdown involves a big waste of fuel since, in making sure that enough is blown down, one is almost certain to blow down too much.

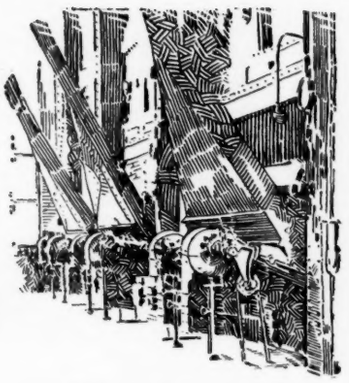
With most feed waters some blowdown is necessary, but it should be scientifically controlled to avoid unnecessary waste. Perhaps the most satisfactory method of control is to measure the concentration of dissolved solids in the boiler water. The proper concentration varies widely with the boiler design, the maximum rate of evaporation and the composition of the feed, but for a given installation there is a fairly definite maximum concentration for satisfactory operation. If the concentration is allowed to get much above this point, operating troubles increase, while if excessive blowdown carries it far below, unnecessary waste results.

If the concentration of dissolved solids in the feed water remained constant and if the boiler evaporated the same weight of water each day, the common practice of blowing down so many "inches" per day would be a scientific procedure. Under actual conditions it necessarily involves some waste. Here is an opportunity for the engineer to save an appreciable amount of fuel. With an instrument to measure concentration, of which several types are available, it is a simple matter so to regulate the blowdown as to keep the concentration of dissolved solids in the boiler water below any desired point. The same instrument can be used in preliminary tests to determine the maximum safe concentration for the given conditions.

Instruments of this type are particularly valuable where the fireman is inclined to be careless. With no check on the blowdown he may feel that an unnecessary loss of one or two per cent, while really an important item with present-day fuel prices, will remain unnoticed in the grand total of fuel consumption. A concentration indicator or meter will leave the operator no excuse for this waste.



Practical Ideas *from* Practical Men



Hydrogen Gas and Electric Boilers

A curious explosion of a steam radiator in the top floor of an apartment building at Carlinville, Iowa, on Feb. 14, killed one woman and injured a little girl. A subsequent inspection by the coroner, who is an engineer, elicited the following observations:

"The steam boiler is equipped with submerged electrodes and the steam is generated by a three-phase electric current coming from a hydro-electric plant.

"The weather was very cold and the steam was hardly sufficient to keep all of the radiators hot during the coldest hours.

"The radiator which exploded, according to an eyewitness, was almost cold when the lady who was killed opened the pet-cock to let the air out, and as soon as it began to blow walked across the carpet to turn it off, when the explosion took place.

"The girl who was injured had been generating sparks by sliding on the rug and touching the radiator."

The coroner's conclusion was that the steam condensing had left the radiator full of a mixture of oxygen and hydrogen, which was exploded by a spark of static electricity that had jumped from the lady's finger to the explosive mixture. The verdict was rendered according to the foregoing facts.

Will not such an accident be possible if steam is generated by the resistance of water through which current passes? It is claimed that submerged electric generators are practically 100 per cent efficient, neglecting radiation, as all the heat generated is absorbed by the water, yet any current passing through water decomposes a certain amount of H_2O and alternating current generates both H and O on the same electrode which in a steam heating system must in time separate and remain confined as an explosive mixture. Moreover, what amount of the current is used to decompose the water and what amount is used to heat it?

Perhaps we might get an expression of opinion from the builders or users of electric steam generators as to the possibilities or impossibilities of such an accident.

Clinton, Iowa. C. E. SARGENT.

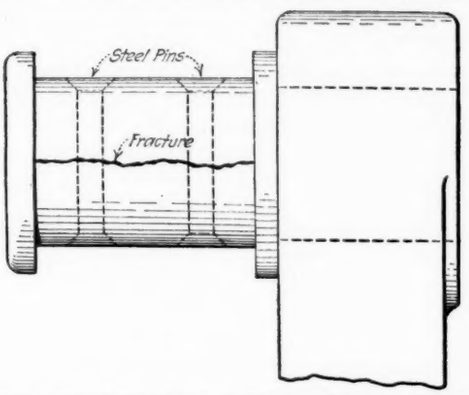
Repair of a Split Crankpin

The crankpin of a 500-hp. engine for a long time had been giving trouble on account of heating. Often it had been necessary to turn a hose on the pin to prevent a shutdown before the close of the day's work. The engineer could discover nothing wrong with the pin; it was square with the crank and was round and smooth. Finally, the superintendent of the plant ordered the troublesome pin removed and a new one put in.

But the engineer was not entirely satisfied that a new one was needed. As a last resort he examined the pin with a magnifying glass and found a fracture extending lengthwise of the pin almost from one collar to the other. The line of the fracture was so faint as to be almost undiscernible.

That explained the difficulty. The expansion of the pin as it warmed up to a running heat would cause it to spread out on each side of the fracture, thus making it bind in the boxes and cause excessive heating.

The pin was repaired as shown in the illustration. Two $\frac{3}{8}$-in. holes were drilled through it perpendicular to



CRANKPIN REPAIRED BY INSERTING TWO STEEL PINS AT RIGHT ANGLES TO THE FRACTURE

the fracture. The holes were countersunk and filled with close-fitting steel pins, heated to redness and riveted over at the ends. The riveted ends were then filed down to the curvature of the pin.

St. Louis, Mo. A. J. DIXON.

Troubles Experienced in Pumping Hot Brine

In the operation of our plant hot concentrated liquor containing potassium chloride, sodium chloride, sodium sulphate, sodium carbonate and borax, at 175 deg. F., is pumped from one evaporator to another with centrifugal pumps, and we experience difficulty in keeping packing (of which we have tried many kinds) in the stuffing box. Also the liquor in which there is salt in suspension, cuts out the packing in a very short time.

We cannot get water in the pump water seal, as the pressure on the pump forces it out, and if we use water at a greater pressure than the pumping pressure, it is carried over with the liquor. It has been our experience that metallic packing scores the shaft, and of

course the use of brass is out of the question. Possibly some readers of *Power* who have had experience with concentrated hot-brine pumps can suggest a satisfactory type of packing. M. C. COCKSHOTT.

Trona, Calif.

Another Score for Compulsory Boiler Inspection

The illustrations herewith show the results of a boiler explosion that occurred recently in a wood-working plant in a Mississippi town and that was undoubtedly caused by a series of bad combinations; namely, an inaccurate pressure gage, an old-style ball-and-lever safety valve, and a new attendant unfamiliar with those conditions.

The boiler was of the horizontal return-tubular type of 300 sq.ft. heating surface set in a battery with a boiler of the same type of 600 sq.ft. heating surface. Both boilers were operated at 100 lb. pressure. On the morning of the accident, which was on Monday, the water was found to be too low for the night watchman to raise steam, so he proceeded to cut this one out and fire the other one as usual. The boiler on which the explosion occurred was filled with a hose later and fired up, but as one gage served both boilers it was connected to the larger one and that left the pressure on the smaller boiler merely a matter of guess. However, about two hours later the foreman decided it should have pressure enough by that time and ordered them cut together. About ten minutes later the explosion occurred, killing one man and injuring another.

Fig. 1 shows the boiler house after the explosion, also the other boiler still in place with most of the brickwork blown from around it.

Fig. 2 shows the exploded boiler where it landed in a small creek, and just above it can be seen a short portion of the cross supporting timber with the hook still attached.

This boiler had only a few months before been retubed and the rear end of the tubes were beaded but the front ends were not, and when the explosion occurred the tubes were pulled out of the front sheet, giving it a skyrocket effect, carrying it 200 yards or more, clearing in its flight a telephone trunk line set up on 50-ft. poles and finally rolling down the banks of the creek to the position shown in the picture.

Undoubtedly, this boiler was never intended for

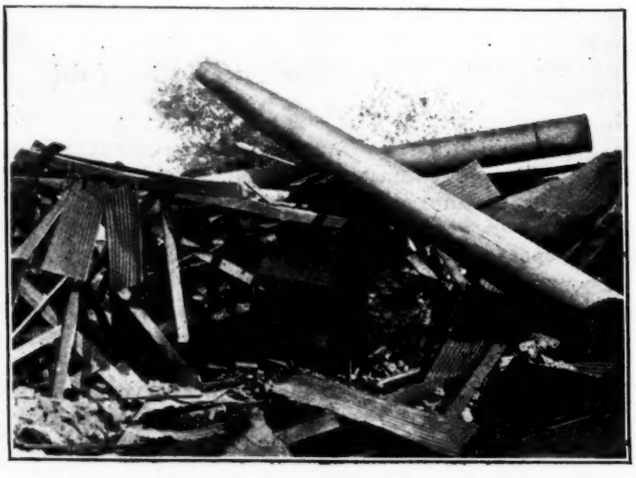


FIG. 1—VIEW OF BOILER HOUSE AFTER EXPLOSION

FIG. 2—BOILER SHELL AFTER EXPLOSION. SEVERAL TUBES WERE PULLED OUT OF THE FRONT SHEET

100-lb. pressure, being a lap-seam, single-riveted ⅜-in. sheet construction, and about half that pressure would, I believe, have been all an inspector would have allowed for it. R. S. GALLAGHER.

Jackson, Miss.

Caustic Embrittlement of Boiler Metals

Within the last decade a number of boiler explosions have been charged to the embrittlement of steel from caustic soda, as the result of using artesian waters containing carbonate of soda or the excessive use of boiler compounds made up largely of this salt.

Maintenance costs on boilers affected by caustic embrittlement are tremendously high, and power companies, steam-boiler manufacturers, state universities and others interested are spending much money in an effort to diagnose and cure this strange malady.

In view of these facts it would seem that a full and frank discussion of this problem should be carried on through the columns of *Power*, in order that every engineer who has had any experience with caustic embrittlement be given a chance to submit his views on the matter and offer any suggestions that may occur to him. Such a discussion at this time would prove very interesting, and no doubt some new data would become available.

Although there has been some dispute as to the real cause of the resultant cracks, it is now generally conceded that sodium carbonate (Na_2CO_3) in the feed water is the chief cause. This mineral at a certain temperature (boilers operating at 150 lb. steam pressure or less seem to be immune) changes in part to the hydrate or caustic soda (NaOH), which deposits in the seams and attacks the metal. The hydrogen that is produced is in the nascent state and, having a natural affinity for metals, is occluded by the boiler shell, and brittleness is the result.

In boilers of the crossbox type this caustic soda usually settles into the pocket that is formed between the shell and crossbox, and the first cracks that appear are usually from a rivet in the outer row to the edge of the crossbox flange. These cracks are not as a rule very troublesome until several are formed, with possibly one or more cracks in the inner row extending to rivets in the outer row. At that time the affected part will begin to leak, and in a short time the cracks will

join, forming a girthwise crack the length of which will depend on the number of rivets affected. It has been my experience that these cracks will be from ten to fifteen inches long when they first become joined in one. One prominent company which manufactures boilers of this type has remedied this condition by installing an extra steel pad between the crossbox flange and the drum shell and calking inside and outside. This prevents the formation of a pocket.

The boilers affected represent all the leading and reputable manufacturers, and it is hardly likely that all of them could put out unreliable products in the same region, if at all. One case in point is of a 48-in. oil-field boiler of the locomotive type, which upon examination revealed a girthwise crack 52 in. long. Another case is of a 10,000-sq.ft. water-tube boiler which, after approximately one year in service, revealed upon examination innumerable small hair-line cracks below the water line, nearly every one of which started from a rivet or joint. In many cases they were so small that they could not be seen without a magnifying glass. A section of plate taken from this boiler presented, upon being split in two, a uniformly crystallized appearance, and internal cracks were noticed which otherwise could not have been seen.

One larger power company has replaced to date approximately twenty embrittled drums. Another small company has replaced at least four whole drums and numerous end sections, and this same proceeding is being repeated almost daily throughout the southeastern part of the United States.

The proper name for these cracks seems to be the cause of considerable confusion. Some claim that they should be called "fire cracks," others say "caustic cracks," and still others claim they are "hydrogen cracks." In my opinion the term "caustic cracks" is the proper one because it has been proved that the boiler metal becomes thoroughly impregnated with caustic.

At the same time it is inconceivable to me that fire cracks could occur in the rear end of a boiler that is properly set over an oil-burning furnace. Delayed or secondary combustion might have this effect if sustained long enough, but usually this condition is found only when the boilers are operating under heavy overloads such as would occur during the peak period. Under such conditions the velocity of the gases is so high that the tendency is to cut corners or short-circuit if possible. Obviously, this would prevent the flame from coming in actual contact with the shell and causing fire cracks. The term "hydrogen cracks" is, of course, technically correct, as the embrittlement is doubtless caused by occluded hydrogen. However, as the hydrogen is the direct result of the decomposition of water by sodium, it would seem, to the practical mind at least, that the term "caustic cracks" is nearer correct than "hydrogen cracks" because in a sense it expresses both cause and effect.

Before considering the installation of any apparatus to be used for removing sodium carbonate from feed waters or to neutralize it before it enters the boiler, it might be well to determine first if there is available some other supply of water that would prove satisfactory. Sodium carbonate and artesian well water are the two things that were found common to all plants effected by caustic embrittlement. One plant changed from creek water having no sodium carbonate but heavy in scale-forming material, to artesian water that contained eleven grains of sodium carbonate per gallon, and immediately had trouble with embrittlement. A big boiler plant supplying steam to a sugar mill and using artesian water, was troubled by embrittlement, but upon changing to bayou water the trouble immediately stopped. Some companies are drilling test wells as deep as 1,300 ft. and are taking samples for analysis in each water-bearing stratum with some degree of success. Even shallow ponds and surface water in some parts of the country contain a little alkali, but the proportion is very low, and these sources should prove the most acceptable when available.

To choose between scale and caustic embrittlement should be only a matter of simple mathematics, and it is a fact of particular interest that where much scale-burning material is present (particularly calcium sulphate), no sodium carbonate will be found. In plants where there is none but artesian well water available, a light treatment of magnesium sulphate ($MgSO_4$), the proper amount to be determined by test, might prove helpful, and it is also thought that a suitable lime treatment might help.

Before magnesium sulphate is introduced into the boiler, it should be ascertained that sodium carbonate is also present, because if present alone its only action would be to react with the water itself when the salt separates out on the boiler plates at the water's edge. Magnesium sulphate at this point reacts with water to produce magnesium hydroxide ($Mg(OH)_2$) and sulphuric acid (H_2SO_4). The magnesium hydroxide is insoluble and will form scale, and the sulphuric acid will attack the boiler metal. If sodium chloride ($NaCl$) is present when magnesium sulphate is introduced into the boiler water, it will react to produce sodium sulphate (Na_2SO_4) and magnesium chloride ($MgCl_2$). Sodium sulphate is harmless except that it helps to increase the feed-water concentration, but magnesium chloride is a very soluble salt and will react at the water's edge to produce magesium hydroxide ($Mg(OH)_2$) and hydrochloric acid (HCl). This acid will attack the metal below the water line, and if the solution is concentrated enough, it will distill out and corrode the boiler above the water line. These reactions are possible only under certain conditions, but they are mentioned here to show possible causes of corrosion.

The cause of caustic embrittlement is thoroughly understood, but as far as is known no satisfactory method has yet been found which will in general successfully protect boilers from its ravages and remove the danger element. Boiler plants that have installed expensive apparatus to be used in combating it are still having nearly as much trouble as ever.

It is the writer's intention in this letter to touch only roughly on the subject mentioned, the main idea being to form the nucleus of what will probably prove to be a very interesting discussion through the columns of this, the leading steam power-plant journal. If all who have had experience with caustic embrittlement will give just a little accurate data and some of their personal practical experiences, it is thought that the combined experiences and thought will be of great practical value in solving this engineering problem.

Houston, Tex. R. E. GLEASON.

[There are many opinions as to the cause of "caustic embrittlement," the foregoing letter expressing one point of view. The Bureau of Standards is conducting an investigation to settle the matter.—Editor.]

Comments from Readers

Using Shims Instead of Wedges for Leveling Bases of Steam Turbines

With reference to the article by Edgar C. Barker, Sr., in the Jan. 9 issue on the use of shims instead of wedges in connection with the setting of bases of heavy machines, the question comes up as to whether it would not be better and more desirable to use shims of triangular shape (in plan) with three screws instead of four as used by Mr. Barker. In addition to the slight saving in cost and labor in making the shims, it is to be noted that a plane surface can be much more readily and accurately determined by means of three points than by the use of four.

This matter is often overlooked in connection with different leveling operations and would not be important if it did not involve (as it generally does) increased complexity and decreased accuracy.

Natchez, Miss. WALTER C. CAREY.

Muriatic Acid Effective in Removing Scale from Pipes

Referring to the letter by H. M. Toombs in the Feb. 20 issue, on muriatic acid effective in removing scale from pipe, I have found it equally effective for removing scale from a surface condenser which was so badly scaled that some of the tubes were entirely closed. We made a solution of one part muriatic acid to seven parts water and poured this into the condenser through a pipe and funnel until the condenser was full. Action started almost immediately, for by the time the condenser was half full it was too hot to bear your hand on it. After emptying and refilling with the solution three times, the tubes were perfectly clean.

This treatment did not affect the gaskets or tube packing in the least. We also use the same method for cleaning scale out of water jackets on gas- and oil-engine cylinders with equally good results, and I am satisfied that anyone troubled with a scale consisting chiefly of lime will find muriatic acid (hydrochloric) the simplest and best method of removing it.

St. Louis, Mo. H. R. ROCKWELL.

Should Steam for Heating and Process Be Charged to Power-Plant Costs?

I should like to add to the comments of M. E. Guile in the Feb. 27 issue in replying to the question asked by Mr. Maconnell in the Jan. 16 issue, "Should Steam for Heating and Process be Charged to Power-Plant Costs?"

Any concern that pretends to keep cost accounts of manufacturing or power-plant records must debit and credit the power plant for all receipts and disbursements of its product.

The power plant of any establishment, whether industrial, hotel or large office building, manufactures and supplies a product or several products—steam, live or exhaust, electric current, refrigeration—and credit should certainly be given for every item supplied if a proper record of control figures is kept by the auditor or comptroller.

In some plants where I have supervised, I have found it difficult to convince the comptroller that the power plant had a product to sell and receive credit for—so many concerns consider the power plant an expense, whereas when shown that it is a producing department, it is looked upon in a different manner and accorded its proper place, and the engineer is considered a department manager and treated accordingly.

In many up-to-date establishments the engineer attends the departmental meetings and in some cases under my observation has been able to advise on changes in manufacturing processes that have been the means of saving in the cost of production of the goods manufactured.

In my plant, which is a mercantile building, all costs are kept and include every item entering into the operation of the plant. The plant is credited for electric current furnished for lights and motors for tenants, and for building operation, exhaust steam for heating, makeup live steam for heating, and live steam for manufacturing process. Water for all purposes is metered to the plant and then redistributed with a water meter for each tenant; the boiler water is of course metered separately. All repair work is charged out in its regular manner; this includes steamfitters, plumbers and electrical work. WILLIAM LONG.

Brooklyn, N. Y.

Adiabatic Compression

In *Power*, Feb. 13, under "Comments from Readers," you publish a letter from me. The editor added a phrase to this letter to which I object, as it changes the meaning. In the last sentence of the fifth paragraph of my letter I stated, "With adiabatic compression, no heat could be added to or abstracted from the ammonia during the compression." The phrase, to which I object, modifies this to read, "With adiabatic compression, no heat *save that of the work of compression* could be added to or abstracted from the ammonia during the compression."

Apparently, the only reason for making such a change in a letter that is supposed to reflect the writer's viewpoint, is that your editor thought my statement violated the Law of Conservation of Energy. He correctly reasoned that, if energy in the form of work was put into the vapor during the compression, this energy must manifest itself during compression in some other form, since energy is indestructible. How he could justify its manifestation as "heat added to or abstracted from the ammonia during the compression," is impossible to conceive, as the process was defined as an adiabatic one. An adiabatic process is one in which heat is neither added to nor abstracted from the working substance. As a matter of fact, the energy that

is put into the vapor in the form of work during the adiabatic compression is, of course, not destroyed, nor does it manifest itself in any direct external manner. This energy is stored within the vapor itself. In other words, there is a change in the internal or intrinsic energy of the vapor. That thermodynamic substances do have the capacity for storing and liberating internal energy is beyond doubt. The question as to how the substance stores this energy internally is one involving the properties of its molecules.

Inasmuch as one of your staff took the liberty of making this change, an action which I cannot understand, I would appreciate it very much if you would have a correction published for your readers.

F. C. EVANS, Instructor,
Department of Heat Power Engineering,
Ithaca, N. Y. Cornell University.

[Adiabatic expansion and compression are usually described as a process where heat is neither added to nor taken away from the working fluid. On the other hand, it is well known that during adiabatic expansion the temperature of the working gas decreases and the total amount of heat in the gas is less than before the expansion. Conversely, during adiabatic compression, say of ammonia, the work of compression reappears in the form of heat in the gas, being evidenced by an increase in temperature. It was to avoid this seeming paradox that the clause to which Mr. Evans objects was inserted. It should not be stated that with adiabatic compression no heat could be added to or abstracted from the ammonia during compression without adding at least mentally the qualification, "save the heat equivalent of the work of compression."—Editor.]

Using Shims Instead of Wedges

Replying to George H. Wallace's letter in the Jan. 16 issue, commenting on my article, "Using Shims Instead of Wedges for Leveling the Bases of Steam Turbines," in *Power* of Jan. 9, it is just as essential that a turbine should be securely set and grouted as an engine, for long life and perfect operation. The turbine builders of today, many of whom have been steam-engine men, are aware of this fact and make provisions for grouting the base on the foundation more easily and with more openings both inside of the base as well as outside for pouring in the grout. It is no hard matter to reach with a stick of two or three feet in length any part of the base of a large-sized turbine, and if a dam, as I described in the Jan. 9 issue, has been built around the turbine and the base has been filled above the bottom to an elevation of six inches or even, as I have done in many cases, to one foot, the air under the bearing surface of the base will get out to such an extent that what remains will be of very little consequence.

I might add that if Mr. Wallace had ever grouted in one of the vertical turbines which the General Electric Co. at one time built, I feel confident that he would get over the idea that there is much to be gained in puddling in the grout and also would find it difficult to build any dam for doing a satisfactory job in any other manner than that described in the article.

I have removed turbines for shipment and change of location which had been grouted by the method described and also those that had been grouted as Mr. Wallace mentioned, and I know that the former were just as good and have yet to see one where the grouting had failed. Where old engine practice had been followed and the unit had been grouted down with brimstone (as they called it at one time), otherwise known as sulphur, the latter was as hard as when first put in where the air could strike it, but where the air was not in contact and the base could spring with vibration, the sulphur or brimstone could be blown away as a fine powder, showing that the turbine weight had been carried on the wedges that were placed under it for leveling.

Had the shims and leveling plane scheme been used in the first place, I firmly believe that this particular turbine would have given better service. It has done well since being moved and grouted with a mixture of fine sand and cement in the proportions of 50-50. In this particular case I used what they termed torpedo, or kiln-dried sand wherein the floating qualities for pouring were very close to those of cement, which was mixed in several barrels, pouring it in at all the openings possible at the same time, also being sure that it could move under the base at the time that the space between the foundation and the base is full. Then I filled the base by the openings provided as high as possible, which is higher than can readily be done when a brick dam is used, and which furnished another argument against this dam method. The grout on the outside of the base which has to be cut or broken off, is cement and sand thrown away, and if an erector remains on the road long enough, he will encounter customers that will fight as soon as they see even one sack of cement being used without any good results. If they see one building a brick dam far enough away from the base to permit pushing a stick or wire under it, they begin to start a row. With these things in view and sixteen years on the road erecting turbines and two years as an engine erector, I am convinced that a dam for grouting steam turbines is most easily and best built as originally described.

Power, W. Va. EDGAR C. BARKER, SR.

Seventeenth-Century Waterwheels

In the Jan. 23 issue there was an interesting account of the pumping installation for supplying water to the gardens of Versailles. It may be interesting to readers of *Power* to know that Matchoss, in his "Geschichte-der-Dampfmaschine," makes two interesting references to this installation. In one place he states that it was put in by a carpenter from Leige in 1682 and consisted of no less than 14 waterwheels and 235 suction and pressure pumps which forced the water to a height of 160 meters (525 ft.), which is in substantial agreement with the article in *Power*. He further states, however, that the quantity of water pumped was about 5,000 cu.m. for 24 hours, or at the rate of about 900 gal. a minute. The amount of power required was thus about 150 hp., and according to Matchoss this installation was the largest power plant in existence at the time.

In another part of this book Matchoss again refers to Louis XIV, who desired to find some means for pumping water for his gardens, and states that he employed the physicist Huyghens to work on an installation that would use a sort of internal-combustion motor operated by gunpowder. Although Huyghens made a model of such a machine, nothing of the kind was put in operation. This was worked on, I should judge, some ten or fifteen years before the installation of waterwheels.

San Francisco, Calif. R. C. POWELL.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Space Included in Furnace Volume

In a water-tube boiler with vertical baffles, would the section including tubes in front of the first baffle be rated as furnace volume, or only space below the tubes? C. B. S.

The furnace volume may be considered as the space in which combustion can be completed before the furnace gases are cooled by contact with the boiler heating surfaces. Generally speaking, it is the clear furnace space that is bounded by heating surface or furnace walls up to the beginning of the first pass of the gases beyond the furnace. In a water-tube boiler with vertical baffles the furnace volume would not include the section containing tubes in front of the first baffle, but would be confined to space below the tubes.

Trouble from Water in Fuel Oil

We use fuel oil for firing and have a condition that is giving us trouble. We have concrete underground storage tanks, and there is a percentage of water that will not separate from the oil, but hangs in solution and when heated and agitated through pumping the oil becomes emulsified. How can the condition be overcome? R. G.

When water cannot be separated by allowing the oil to stand a reasonable length of time to allow the water to settle to the bottom of the tank, it can be removed by passing the oil through a centrifugal separator on its way to the furnaces. This method is commonly used for improvement of fuel oils for removal of dirt and water without depending on quiet storage for settling out the impurities.

Relative Value of Exhaust

If the price per 1,000 lb. of live steam at the pressure of 185 lb. gage is known, how can the value of exhaust steam be found and what factors have to be considered? The exhaust steam is discharged by two turbines and a Corliss engine exhausting against 2 lb. gage pressure. W. S.

For conversion of part of the heat of the initial steam into work by either the turbine or engine, each horsepower developed deprives the steam of 2,545 B.t.u. per hour. Under usual conditions, this conversion of part of the heat into work and losses by radiation abstract so much heat that, after being reduced to the pressure of the exhaust, the steam contains considerable moisture, the amount depending on the ratio of expansion and other conditions of operation. The fraction of weight of the initial steam remaining available for circulation as dry saturated steam at the reduced pressure may be known only by deducting from the total weight of the initial steam, or of the exhaust, the weight of water that may be separated out of the exhaust and dividing by the total weight of the steam supplied to the engine and turbines. The amount of water could be determined by weighing the discharge from drips or collected by a separator.

But for most purposes where exhaust steam is used, it is necessary to employ a back pressure relief valve which wastes the exhaust to the atmosphere to prevent a building-up of the back pressure in case the demand is less than the supply, and this introduces uncertainty as to the amount of low pressure steam that has been utilized.

Where possible, as where heating coils are supplied, the best method of determining the amount of steam actually used is to determine the weight of condensate returned.

When the steam is supplied for heating purposes, and no credit is stipulated for return of the condensate, the relative heating value per 1,000 pounds of dry saturated steam at different pressures must be considered to be proportional to the latent heat of evaporation for the respective pressures. The latent heat per pound (weight) of steam at the pressure of 2 lb. gage, or 17 lb. per sq.in. absolute, is 965.6 B.t.u., and for steam at 185 lb. gage, or 200 lb. absolute, is 843.2 B.t.u. Therefore the value per 1,000 lb. of dry saturated steam supplied at 2 lb. gage pressure would be $965.6 \div 843.2 = 1.146$ times, or about 15 per cent higher than when supplied at the pressure of 185 lb. gage.

Temperature of Steam at Reduced Pressure

What would be the temperature of steam at 250 lb. gage pressure, superheated 150 deg. F., after it is discharged through a reducing valve with the pressure reduced to 125 lb. gage; and when reduced to 150 lb. gage; also if dry saturated steam at 250 lb. gage is discharged through a reducing valve, what would be the temperature when the pressure is reduced to 150 lb. gage. J. C.

By reference to tables of properties of superheated steam it may be seen that dry saturated steam at the pressure of 250 lb. gage, or 265 lb. per sq.in. absolute, has a temperature of 406.2 deg. F. and each pound (weight) contains 1,202.3 B.t.u. above 32 deg. F. When superheated 150 deg., the temperature becomes $406.2 + 150 = 556.2$ deg. F., and the heat per pound (weight) becomes 1,290.4 B.t.u. above 32 deg. F.

From passing through a pressure-reducing valve there is neither gain nor loss of heat, except the very small quantity of heat lost by radiation, which may be neglected. Hence, immediately after conversion to a lower pressure each pound of the steam still would contain practically 1,290.4 B.t.u. above 32 deg. F.

Referring to tables of properties of superheated steam that give values for each 10 degrees of superheating, it may be seen that for 125 lb. gage, or 140 lb. per sq.in. absolute, the heat content of 1,290.4 B.t.u. is between 1,288.3 B.t.u. for the temperature of 533.1 deg. F. and 1,293.2 B.t.u. for the temperature of 543.1 deg. F., showing 4.9 B.t.u. increase of total heat for 10 deg. F. increase of temperature.

Hence, by interpolation, the temperature for 1,290.4 B.t.u. would be

$533.1 + (1{,}290.4 - 1{,}288.3)\ 10 \div 4.9 = 537.4$ *deg. F.*

In the same manner the temperature corresponding to reduction of the pressure to 150 lb. gage or 165 lb. per sq.in. absolute is found to be 541.6 deg. F.

When dry saturated steam at 250 lb. gage, or 265 lb. per sq.in. absolute, and containing 1,202.3 B.t.u. is passed through a reducing valve and the pressure is reduced to 150 lb. gage, or 165 lb. per sq.in. absolute, from inspection of tables of superheated steam it may be seen that for 165 lb. absolute a heat content of 1,202.3 B.t.u. is between 1,201.4 B.t.u. for the temperature 376 deg. F. and 1,207.6 B.t.u. for the temperature 386 deg. F., showing 6.2 B.t.u. increase for 10 degrees increase of temperature. Hence, by interpolation, the temperature for 1,202.3 B.t.u. per pound (weight) when the pressure becomes reduced to 150 lb. gage would be

$376 + (1{,}202.3 - 1{,}201.4)\ 10 \div 6.2 = 377.4\ F$

As the temperature of dry saturated steam at the pressure of 150 lb. gage is 366 deg. F., there would be 377.4 — 366 = 11.4 degrees of superheat.

Cushioning of Duplex Steam Pump

In a duplex steam pump, how is cushioning on the exhaust obtained? R. L. G.

The ordinary duplex steam pump as shown in Fig. 1 is provided with five ports, the outer ports *k* being steam ports and the inner ports *l* and the central exhaust discharge port, which by movement of the valve is alternately in communication with the ports *l*, are exhaust ports. The piston in approaching either head covers the ports *l* and steam then remaining on the end of the cylinder in becoming compressed in the end of the cylinder and the steam passage *k* acts like a cushion in bringing the piston to rest.

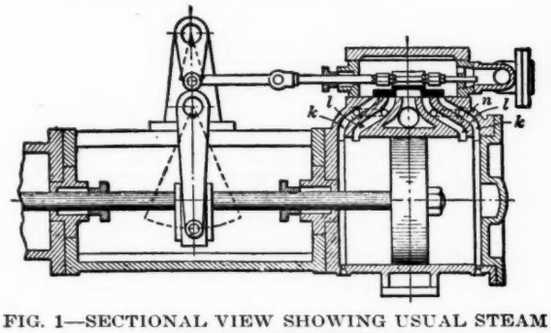


FIG. 1—SECTIONAL VIEW SHOWING USUAL STEAM PORTS OF DUPLEX PUMP

On larger pumps a passage is provided between the ports *k* and *l* and a valve *n* is inserted which can be opened to allow escape of part of the compressed steam to the exhaust passage *l* and thereby reduce the amount of cushioning. As the ports *k* are for steam admission only, they can be made a little smaller than the exhaust ports *l* and although most pumps are provided with this arrangement, it presents considerable waste room or clearance.

In some instances much of the clearance is saved by having only one main port at each end as at *a*, Fig. 2, to serve as both steam and exhaust ports, terminating a short distance *c* from the head to form the cushion and a small auxiliary port *b* is added close to the cylinder head. The port *b* then admits steam behind the piston for starting, after which the port *a* becomes uncovered and the full amount of steam is admitted. For this arrangement the slide valve must be designed so as to open port *a* for steam or exhaust and port *b* for

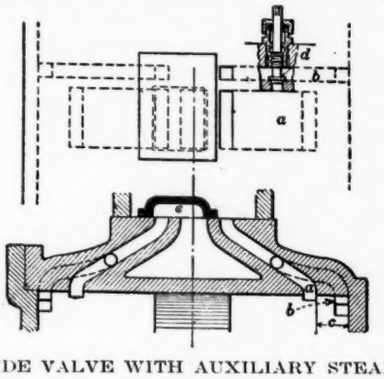


FIG. 2—SLIDE VALVE WITH AUXILIARY STEAM PORT *b*

steam only. This, as indicated in plan, Fig. 2, is accomplished by making the cavity *e* only as wide as *a*, while the width of the whole valve must be sufficient to cover both ports. The compression may be regulated by a cushion valve *d* connecting ports *a* and *b*, and as shown, the port *b* always is ready for steam admission whether the cushion valve is open or closed.

Efficiency of Boiler, Furnace and Grate

A test of our water-tube boiler in a continuous run of 24 hours showed total evaporation of 142,036 lb. of feed water at the average temperature of 170.6 deg. F., evaporated into steam at the average pressure of 67.11 lb. gage, with 5 per cent moisture and consumption of 16,035 lb. of coal having a heat value of 12,000 B.t.u. per pound, using a mechanical stoker and Dutch oven furnace. What was the combined efficiency of the boiler, furnace and grate? G. C. H.

Evaporation of 142,036 lb. of feed water for consumption of 16,035 lb. of coal would be 8.8578 lb. of water evaporated per pound of coal, under actual conditions. From interpolation of the steam tables, it may be found that the latent heat of evaporation of a pound of dry saturated steam at the pressure of 67.11 lb. gage, or 81.81 lb. per sq.in. absolute, would be 899.14 B.t.u., and the heat of the liquid would be 282.72 B.t.u. As the steam contained 5 per cent moisture—that is, had a quality of 0.95—each pound (weight) of the steam must have contained $282.72 + (899.14 \times 0.95) = 1{,}136.9$ B.t.u. Hence with the feed water at the average temperature of 170.6 deg. F., the average heat received per pound of the feed water was $1{,}136.9 - (170.6 - 32) = 998.3$ B.t.u., and if the coal used contained 12,000 B.t.u. per pound, the efficiency of boiler furnace and grate was $(8.8578 \times 998.3) \div 12{,}000 = 0.7368$, or 73.7 per cent.

[Correspondents sending up inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Easy Lessons in Engineering

How to Construct a Formula

An article on page 266 of the Feb. 13 issue told how to solve a simple engineering formula. As there stated, a formula is nothing but an abbreviated rule in which words are replaced by symbols.

These symbols are of two kinds. First, letters are used to stand for various quantities. In general, any letter may be used to represent a quantity. For instance, "tons of coal" might be represented by T (for tons), W (for weight), C (for coal) or any other letters such as X, a, B, h, etc. As a rule, however, engineers prefer a letter that reminds them of the quantity it represents.

The other symbols used are those that indicate operations such as multiplication, addition, etc. These are largely the same as those used in arithmetic. For example, + means *add* and — means *subtract*. Powers and roots are expressed exactly as in arithmetic. The multiplication sign is generally omitted, it being understood that when two quantities are placed side by side, with no other operation indicated, they are supposed to be multiplied. For example $6ab$ means $6 \times a \times b$. The sign ÷ may be used to indicate division, but it is customary to write the two quantities involved as the numerator and denominator of a fraction. That is, instead of writing $6 \div a$, we would ordinarily write $\frac{6}{a}$, which means the same thing, since the value of any fraction is its numerator divided by its denominator.

Another symbol very common in algebra is the parenthesis ( ), which simply means that everything inside of it is to be considered as a single quantity. For example $(2 + 10)(3 + 4)$ means that the single quantity inside the first parenthesis is to be multiplied by the single quantity of the second. The first step is to reduce what is inside each parenthesis to as simple a form as possible. Doing this, $(2 + 10)$ reduces to (12) and $(3 + 4)$ reduces to (7). Then we have (12) (7), which is 12×7, or 84. Sometimes one parenthesis is inside of another. These can easily be "simplified" by working from the inside out. The outer parenthesis is usually given a different form, say that of a bracket [ ], so that it will not be confused with the other. As an example consider this:

$$12 + 4\left[\frac{6}{3} + 5(9 - 3)\right]$$

Starting from the inside and working out, this reduces in the following steps:

$$12 + 4[2 + 5(6)]$$
$$= 12 + 4[2 + 30]$$
$$= 12 + 4[32] = 12 + 128 = 140$$

All this is only the *language* of algebra. Turning now to practical uses, we have seen that one important application is in the solution of engineering formulas. Another use is in making one's own formulas.

The first step in making a formula to solve any kind of a problem is to examine the facts and put them in the form of an "equation," which is merely a statement that something is equal to something else. If this original statement is true, anything worked up from it by the rules of algebra will also be true.

To get the idea let us work up a formula for the volume in gallons of any vertical cylindrical tank when the diameter and height are given in inches. Use the following abbreviations:

D = Diameter of tank in inches;
H = Height of tank in inches;
G = Gallons capacity.

Then the area of the top circle in square inches = 0.7854 times the diameter squared = $0.7854D^2$. The volume in cubic inches = top area in square inches times height in inches = $0.7854D^2H$.

Since there are 231 cu.in. in one gallon, the gallons contained are equal to the cubic inches divided by 231, or $0.7854\ D^2H \div 231$. This may be abbreviated as follows:

$$G = \frac{0.7854D^2H}{231}$$

If this formula is to be used more than once, it will pay to simplify it by reducing the two numbers, or "constants" as they are called, to a single constant in the following manner:

$$G = \frac{0.7854D^2H}{231} = \frac{0.7854}{231}\ D^2H$$
$$G = 0.0034\ D^2H$$

The formula is now in such a form that the capacity in gallons can be figured with a minimum of labor when the two dimensions (in inches) are given. To illustrate the use of this formula, suppose a tank of this kind is 85 in. high and 60 in. in diameter. In other words, $H = 85$ and $D = 60$. Then

$$G = 0.0034 \times 60^2 \times 84 = 0.0034 \times 3{,}600 \times 84$$
$$= 12.24 \times 84 = 1{,}028 \text{ gal.}$$

As another problem, let us derive a formula for the weight, in pounds per running foot, of a wrought-iron pipe whose internal diameter and wall thickness are known. The following abbreviations will be used: d = internal diameter, inches; t = wall thickness, inches; W = weight per foot, pounds.

Then, since one cubic foot of wrought iron weighs 0.28 lb., we have:

$W = 0.28 \times$ cu.in. of metal per ft. of length

The pipe is a hollow cylinder, so the volume is equal to the area of the end ring times the length (12 in.) The formula is then derived in the following simple steps:

W = 0.28 × area of end ring × 12 = 3.36 × area of end ring = 3.36 × average circumference × t = 3.36 × average diameter × 3.1416 × t = 10.6 × t × average diameter

$$W = 10.6t(d + t)$$

Operating Characteristics of Ammonia Condensers*

Relative Advantages and Disadvantages of the Four Types of Ammonia Condenser in General Use, With Comments on Features of Interest from a Practical Point of View

BY O. A. ANDERSON
Motive Power Department, Armour & Company

EVERY heat unit that is to be removed from refrigerated rooms must be exchanged and transmitted to the water passing over the ammonia condenser, less any heat that may be carried off by the air through conduction. It is apparent, then, that the ammonia condenser is nothing more than a heat exchanger. In the case of a perfect heat exchange in the condenser, barring foreign gases, the condenser pressure will correspond to the temperature of the water passing over it.

From a practical viewpoint the engineer is interested in the lowest possible condenser pressure, minimum investment, long life of the equipment, convenient means of removing scale from the water surface, elimination of the possibility of ammonia leaks, and continued activity of the entire ammonia condenser installation, properly divided among all the ammonia-condenser stands.

CLASSIFICATION OF AMMONIA CONDENSERS

Ammonia condensers may be classified into four general types—atmospheric, double-pipe, tubular and submerged condensers. The atmospheric type may be divided into two classes, top and bottom supply. There are a number of specially designed condensers employing different methods for removing liquor, but these may be placed under the general groups given.

The top-supply atmospheric type is the most primitive form of condenser. The water passes over coils parallel with the direction of flow of the ammonia vapor, the coldest water coming first in contact with the hottest vapor and the outgoing liquor coming last in contact with the warmest water. Originally, the atmospheric top-supply condenser was built 33 pipes high to the stand, and even today certain of these installations are still in service. In recent years, however, the tendency has been to reduce the height of stand. Conservative engineers have been using an arrangement of 24 pipes, and a number of plants are now in operation with 18 pipes and some with 12 pipes of vertical height.

Careful investigation has shown that with almost any temperature condition the water removes little if any heat from the vapor after it has passed over 18 pipes in the stand. Where such conditions can be verified, it is obvious that the coils below the point where the water does not increase in temperature become an unnecessary investment. One point to be considered in this case is the amount of water discharged over the condenser. With a limited supply an unfair test would be made.

QUANTITY OF COOLING WATER REQUIRED

In Chicago a large number of the smaller ice plants require spray ponds or cooling towers, as cold water from deep wells is not generally available. To take advantage of the lowest possible water temperature, the practice in the case of spray ponds is to circulate an excessive amount of cooling water over an ammonia condenser 12 pipes high. Up to 4 gal. of water per minute per ton of refrigerating capacity in operation is circulated. This results in a 4-deg. spread in temperature between the water going on and off the ammonia condenser. With this low temperature range the spray pond can handle efficiently the water in question and bring about in the water nearly wet-bulb temperatures. The result is that the condenser pressure is actually lower than in the case of a 7 to 12-deg. temperature spread, as it is impossible for the spray pond to reduce the temperature to correspond with the spread at the condenser.

*Abstract of paper read before the Chicago Section of the American Society of Refrigerating Engineers, Jan. 30, 1923.

An objection to the atmospheric top-supply ammonia condenser is that the counter-current principle of heat exchange is not employed. However, in the case of condensers 12 pipes high, where the water is actively taking up heat over the entire surface, except for the water that spills over, this defect is not so objectionable as with higher-pipe condensers. The one outstanding advantage of the atmospheric condenser is that the distribution of ammonia vapor to the different stands is satisfactory and simple, and the added capacity of the condenser stands in winter may be employed advantageously.

The bottom-supply atmospheric type of condenser takes advantage of the counterflow principle of heat exchange. Hot ammonia vapor coming into the bottom of the condenser coil becomes submerged and condenses in a body of ammonia liquor, the conductivity of which is greater than that of the vapor. The liquor trickling down the inner surface of the pipes affords a more rapid transfer of heat from the vapor in the pipe, so that the surface is more effective and a less number of feet of pipe per ton of refrigerating capacity is required.

In practice there has been considerable variation in the amount of 2-in. condenser piping installed per ton of refrigerating capacity. Conservative engineers provide 60 ft. and others allow from 40 down to 20 ft. of 2-in. pipe per ton. It is obvious that the height of the condenser and the employment of the counterflow principle are determining factors in the surface required.

ARRANGEMENTS FOR DRAINING THE LIQUOR

For draining the liquor from different points of the condenser stand, there are a number of arrangements all following the same general principle. Many of these bottom-supply installations are giving excellent results with not over 50 per cent of the surface required by the standard top-supply condenser for corresponding water temperatures and air conditions.

In some plants, however, trouble has been experienced from the improper distribution of the ammonia vapor to each of the different condenser stands. When a plant with this type of condenser is operating at less than its full capacity, or with an approach to wet compression, the discharge temperature not being over 180 deg., it has developed frequently that a large number of the coils have filled up with ammonia liquor and have been idle, so that only a part of the surface remains in active service. It would appear that care must be exercised in not installing excessive condenser surface with this type of condenser.

One advantage of the atmospheric-type ammonia condenser is, that the water in passing over the coils is exposed to the atmosphere and evaporates so that an added cooling of the water takes place. There is also the advantage of the air cooling at such times as the air is cooler than the water. In fact, in many plants in the Chicago district and north, ammonia condensers are operated with very little water during the winter season.

In the smaller plants where the condenser is placed in the engine room, the double-pipe ammonia condenser is more generally used. It is operated on the counterflow principle, and the heat transmission is efficient. One objection for large plants is that freeze-ups in the winter time might take place and an excessive loss result above any savings that might be made in the original investment, compared to the atmospheric condenser. Another objection for large installations is the impracticability of removing return bends for cleaning. An advantage is that external corrosion of the equipment is practically

eliminated. In small plants the scale may be removed conveniently by running a vibrator or boring tool through the water coil or flushing with high-pressure water in the case of soft scale. This type of condenser is seldom installed in stands over 12 pipes high, and the temperature range of the water passing in and out is usually from two to three times that of the atmospheric type of condenser, bringing about economical use of the surface.

Tubular-Type Ammonia Condensers

The tubular-type ammonia condenser is made up of a large shell with heads on each end, in which are inserted and expanded water circulating coils. A number of shells are placed one above another, forming a vertical stand of five or seven shells. The ammonia is condensed in the large shell, and the water is passed from one shell to the other in the same manner as in a standard double-pipe condenser. The one advantage of this type of condenser is that cleaning may be done conveniently by removing the heads and running a vibrator through the tubes, there being no ammonia joints to dismantle. Furthermore, external corrosion is practically eliminated, as the outside of the shell may be painted conveniently from time to time. One disadvantage of this type of condenser, as well as of double-pipe condensers, is the inability of using the cooling effect, brought about by the evaporation of some of the water in passing over the condenser. This, however, may be offset by added temperature rise, or additional heat removed per gallon of water, as compared to the atmospheric construction.

Another disadvantage of the tubular and the double-pipe condensers is the possibility of ammonia leaks taking place over a given period without notice. Ammonia leaking into the water may be carried off and discharged to the sewer or to a cooling tower without notice of the operating engineer. Therefore, with such equipment it is important that tests to determine leakage be made regularly with litmus paper. This type of condenser has not been used as extensively as other condensers, and its future progress will be governed by the question of ammonia leakage and its adaptability to different water conditions.

The submerged condenser is not used much, but frequently the discharge gas from the compressors is passed through submerged coils in the water tank in order to remove the superheat previous to passing to the condensers. With the submerged condenser the counterflow principle is again employed. It is a clumsy apparatus requiring a substantial structure for mounting, and all of the water does not come in direct contact with the coils. Another disadvantage is that it is difficult to keep the coils clean.

In the foregoing outline of the characteristics of the different types of condenser, clean pipe surfaces were assumed. This condition obviously does not exist in practice, so that the life of the equipment, means of cleaning, ammonia leakage, etc., must be considered.

Disadvantage of Atmospheric Condenser

One inherent weakness of the atmospheric-type condenser is the rapid depreciation of the piping, due to the exposed wet surface. In places where careful cleaning and painting may be carried out, the condenser piping may last fifteen years, although the average life is probably in the neighborhood of ten years. With this rapid deterioration in mind the highest grade of wrought-iron pipe will far offset in longevity the extra cost in purchasing the higher grade material. Galvanizing should be considered in places where the water is comparatively free from scale, as the corrosion and pitting will be less. Where there is a heavy accumulation of scale, it is questionable as to whether galvanizing will do any good.

Tubular and double-pipe ammonia condensers are favored with longer life, as there is no part of the surface exposed to the atmosphere which may not be kept in a dry, clean and painted condition, the depreciation depending upon the life of the water tubes, which are turbined or scraped from time to time. In the tubular condenser the life of the tubes depends on the amount of rolling required to keep them tight.

From a cleaning viewpoint the atmospheric type of condenser is not particularly accessible unless the stands are spaced liberally so that the lower tubes may be reached with a scraper. In many locations the accumulation of scale from bad water is so great that a tubular or double-pipe ammonia condenser would be impracticable. Where scale from the cooling water accumulates in moderate quantities and is of a harder nature, it is more convenient to remove it with a turbine or scraper from the water coils of the tubular condenser than from the exterior pipe surface of atmospheric condensers.

Protection against leakage in the atmospheric condenser is effected by reducing the number of ammonia joints. It is found practical to make up ammonia condenser coils with screwed return bends in sections of six pipes each. This reduces considerably the number of joints, compared to the old type of condenser having a set of companion flanges for each pipe in the stand. In the tubular condenser the water coils are expanded into heads at each end of the shell and offset to make a tight joint. There is difficulty, however, in keeping these joints tight owing to the unequal expansion and contraction of the ammonia and water with varying temperatures during the different seasons. Unless special attention is paid to testing the condensing water for traces of ammonia, a leak may continue for a long period unnoticed. With atmospheric condensers ammonia leaks become evident at once to an operator in the vicinity.

In the construction of atmospheric condensers some progress has been made in completely welded units, eliminating entirely all ammonia joints in the stand. If this construction is carried out according to the A.S.M.E. Code, if the cost is not excessive, and it becomes evident that the life of this equipment is relatively longer than with condensers with mechanical joints, the outlook for this construction should be favorable.

In the past anything but sweated joints for ammonia condensers was not considered good engineering. Today litharge and glycerin are proving satisfactory, with the result that erection of condenser equipment in the field is facilitated.

Repairs Under Pressure

Two fatal accidents that occurred recently were directly due to the highly dangerous practice of attempting to repair boilers, steam pipes, and other closed vessels while under pressure.

One of the accidents occurred in connection with a water-tube boiler. This is one of a battery and had been shut down for a time. In the process of putting it in service again, steam had been raised to 130 lb., but the boiler had not been cut in on the line. A leak was discovered around one of the tube caps in the front water leg, and the attendant tried to "roll in" the cap. The cap was a somewhat unusual type, and during the operation it was pushed in, and a stream of boiling water under 130 lb. pressure rushed out directly into the attendant's face. The man was hurled against a coal pile about twelve feet distant and almost instantly killed.

In the other case two men were attempting to stop a leak at the flange of a reducing tee on a steam-pipe line. They had put a packing ring or gasket in place and were tightening the bolts that compress the gasket between the flanges. This caused the steam pipe to pull out of the tee, and the parts separated a distance of about eight inches. The escaping steam blew one of the men off a timber on which he was standing and into a concrete wheelpit. The other man was blown from a ladder, but was able to go to the boiler room and have the steam shut off. On returning to the scene of the accident, it was found that the first man was fatally scalded.

Work of this sort is often done without disastrous results, but there are plenty of examples of fatal cases, and no man who persists in following the practice can tell when his turn may come. Neither has any employer a right to ask a man to risk his life in this way. Delays and shutdowns may cause extra expense, but this should not be considered where human life is endangered.—*The Travelers Standard.*

Applications and Limitations of Thermocouples for Measuring Temperatures*

By IRVING B. SMITH†

FROM the viewpoint of the power-plant engineer temperature measurements may be classified as: Feed water, boiler water, economizer, flue gas, superheated steam, bearings, generator windings, transformer windings and cables. Before treating of each of these applications, the author discusses in his paper the various sources of error that may arise in making temperature measurements with thermocouples. These sources of error have been classified as: Thermocouple calibration, instrument calibration, thermocouple circuit, radiation losses, conduction losses, parasitic emf., temperature lag, cold-junction temperature, measured temperature variable, measured temperature not representative.

Feed Water

The determination of feed-water temperatures is usually made with a mercurial or other type of expansion thermometer. For this and similar applications a thermocouple has been developed which is capable of withstanding the boiler pressure and convenient to install. When supplied

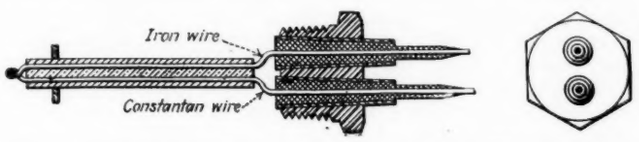


FIG. 1—THERMOCOUPLE FOR OBTAINING TEMPERATURE OF FEED WATER AND BOILER WATER

with an automatic cold-junction compensator it leaves nothing to be desired in the way of reliability and accuracy, convenience of installation and ability to have indications or records or both at distant points. This type of thermocouple is in design quite similar to a gas-engine spark plug. As indicated in Fig. 1, it is so constructed with tapered and insulated leads that the internal pressure acts to prevent rather than produce leaks. For this service no particular care need be taken to avoid errors as, when once properly calibrated, they should hold their calibration indefinitely. The intimacy of contact with the water whose temperature is measured insures against errors. The relatively low temperatures are within the range of copper constantan couples. There may be cases where stray emf. will demand unusual care in insulating the circuit and instrument, but this is a precaution that should be taken in practically any installation.

Boiler Water

The problem of boiler water is similar to that of determining feed-water temperatures, but in this case we have to contend with both high temperatures and high pressure. The same type of thermocouple plug has been found effective. The plug insulation is of mica and, as stated before, the design is such as to preclude the likelihood of leaks starting due to the pressure and temperature to which the plugs are subjected. In fact, owing to improper workmanship some plugs of this type, when they were first being experimentally produced, did leak when first installed. The temperature and pressure to which they were subjected soon closed up the leak. It has been found practical and safe to tap such plugs directly into a boiler. There has been some discussion as to the temperature distribution throughout the tubes and drums of water-tube boilers. Plugs of this type may be tapped into drums and headers and extended into tubes a distance sufficient to enable a study to be made of the relative steaming efficiency of various sections of a boiler. As in the determination of feed-water temperatures no serious errors are encountered in this application.

Economizer

The determination of the temperature of the gases entering and leaving economizers has been made by means of thermocouples arranged in series and so disposed as to secure an approximation to the average temperature of the gas. In this case the various cold junctions are brought out to a convenient point where a compensator is applied.

When such couples are placed both before and after the economizer, a double curve drawing recorder may be employed, indicating at each instant the temperature of the entering gas, the temperature of the exit gas and the drop in temperature through the economizer.

Flue Gas

A continuous record of flue-gas temperatures may be required or it may be desired to control some other element of operation automatically in terms of flue-gas temperature. The thermocouple controller recorder offers a means of accomplishing either or both results.

Kreisinger, in Bulletin No. 145 of the Bureau of Mines, calls attention to the fact that the major error in the determination of flue-gas temperatures is that due to the radiation from the couple to its cooler surroundings unless precautions are taken to prevent such error. He states that under some conditions the error may amount to several hundred degrees in some passes of the boiler. Even in the downtake an error of 25 deg. C. may result from this cause.

Kreisinger pertinently calls attention to two points. First, that the degree of accuracy of gas-temperature measurements depends more upon the judgment of the user of the instrument than upon its correct calibration, and second, because an instrument is correctly calibrated, the readings are too often assumed to indicate accurately the temperature of the gas.

The important point to note in gas-temperature measurements is that the larger the diameter of the couple or its protecting tube the greater the radiation error will be. While it is usually assumed that a heavy couple or a heavy protecting tube markedly lowers the couple temperature by reason of conduction along the wires or protecting tube, such is not generally the case. The conduction error can be made small. The real source of error lies in the fact that a large diameter couple offers a large surface for gain or loss of heat by radiation. With a couple projecting into the hot gases a distance of eighteen inches, conduction error may be ignored. Hence a properly constructed couple for gas measurements should be placed in a substantial steel tube for mechanical strength, but the hot junction of the couple should be exposed for a distance of perhaps six inches. The couple wires should be unprotected for this distance and should be not larger than No. 22 B. & S. gage. With the low temperature of flue gases 200 to 250 deg. C. and with a couple constructed as herein outlined, the gas temperature should be measurable to an accuracy of 3 to 5 deg. C.

In the last pass of a boiler where the temperature of the gas may be 650 deg. C. to 750 deg. C. this type of couple should give a reading not more than 25 deg. C. low. Experience seems to indicate that for the latter measurement a correction approximating 3 per cent will leave only a small outstanding error and for temperatures in the downtake a correction of about 1 per cent will allow for the lowering of temperature due to radiation.

In some tests made for the writer for the purpose of determining the error in flue-gas measurements due to

*Abstract from a paper presented before the Midwinter Convention of the American Institute of Electrical Engineers, Feb. 14 to 16, New York City.

†Leeds & Northrup Company.

radiation, screens or baffles were so located and constructed as to shield the couple from radiation to the boiler tubes. The arrangement is indicated in Fig. 2. The rod A could quickly slide the baffles away from the couple. They could be quickly withdrawn and replaced without disturbing any part of the couple and without loss of time. When readings were made in rapid succession both with and without the baffles, differences of temperature of not over 1 deg. C. resulted. In this case the couples were of No. 22 gage wire. While this method is a satisfactory means of measuring gas temperature at a point in the flue, it does not insure that the measured temperature is a representative one. For this reason multiple couples have been used to secure an average in the same manner as in averaging the temperature of economizer gases.

Superheated Steam

The thermocouple because of its rapid response to changes in temperature, has found an unexpected application in connection with the measurement of temperature of superheated steam. If water is carried along with the steam and strikes the thermocouple, it lowers its temperature suddenly. A continuous record of the thermocouple temperature, therefore, shows sudden breaks, the cause of which is readily recognized. The application to this service was primarily for the purpose of determining the degree of superheat in making acceptance tests of superheaters. It proved very useful in this respect in that it was immediately responsive to any changes due to change in load and was free from suspicion of error due to lead conduction.

For this service the plug-type couple will be found useful. Experience, however, shows that its construction must be carefully attended to in order that it may have sufficient rigidity to withstand the rather high pressure due to the velocity of the steam and the impact of the water.

Bearings

Thermocouples embedded in bearings operate under conditions that insure reliable measurements provided care is taken to secure proper electrical insulation in order that stray currents may not produce errors.

The couple should be set in a hole of such depth that the hot junction is near the running surface and should be made of small wires, otherwise conduction along the wires may result in indicating too low a temperature. Couples constructed and installed as indicated in Fig. 3

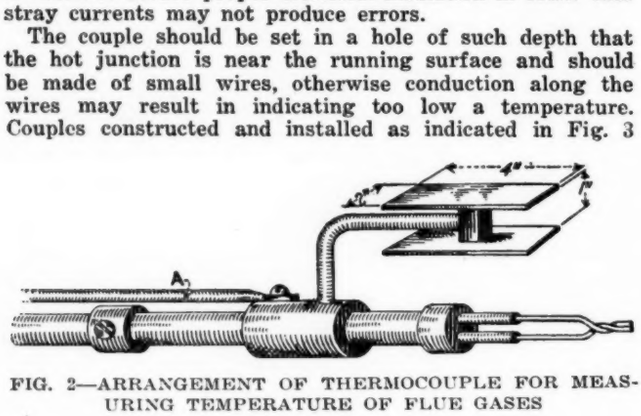


FIG. 2—ARRANGEMENT OF THERMOCOUPLE FOR MEASURING TEMPERATURE OF FLUE GASES

have been suggested, although the writer cannot say whether they have been tried out. This construction grounds the thermocouple since the copper sheath is one element of the couple. Perhaps a better construction would be to use silver for a sheath for only about one inch of length, the balance being made of porcelain or light wall german silver. In this case the couple can be made of fine wire and insulated from the sheath.

It is practical not only to keep a continuous record of bearing temperatures, but to have the recorder furnish a light or bell signal if the temperature rises above a safe limit.

Generator Windings

After a careful analysis of the design of a machine has indicated the probable hottest region, there remains the problem of so locating the couple as to enable the temperature of the copper at this point to be determined.

In service the couple has to be placed outside the insulation and therefore a correction is necessary for the temperature drop through the insulation. Standard corrections for this drop have been adopted in the Standardization rules of the A. I. E. E.

Thermocouples used in generators are always grounded as a protection to the operator, but of course only one ground is permissible since the difference in potential between two grounded points may be large in comparison with emf. generated in the couple. Couples should not have common return leads, as this gives rise to trouble and also makes it more difficult to locate trouble. Furthermore, trouble in any one couple affects the whole system and not simply its own circuit.

It is almost unnecessary to point out that the leads should be individually insulated with good rubber. The fact that

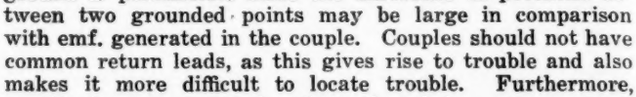


FIG. 3—THERMOCOUPLE FOR INSTALLING IN BEARINGS

the emf. of a thermocouple is but a few millivolts may lead to the inference that a low insulation is sufficient.

Transformer Windings

Thermocouples have not been used to any great extent in this country for measuring the temperature of transformer windings. The resistance thermometer has the advantage that it may be placed in an alternating-current bridge and insulated by means of a special insulating transformer.

Large transformers are usually of higher voltage than generators, and consequently the insulation problem is more difficult. Even if the "hot spot" could be reached, it would not be safe from the viewpoint of life hazard to use underground thermocouples, and it would cause dangerous stresses in the insulation to run grounded thermocouples into the windings in the ordinary manner.

One electrical manufacturing company employs an "artificial hot spot" located in the oil of the transformer and supplied with current from an auxiliary transformer. In this "artificial hot spot" it is safe to place a thermocouple or any convenient type of temperature detector.

Cables

In the last year or two the thermocouple has been used extensively for temperature measurement in cable systems. The thermocouple is valuable in this work because of its extreme simplicity and robustness.

Where it is possible to solder the couples to the lead sheath of a cable before drawing in, the problem is rather simple. The errors to be avoided are those due to stray emf., leaking on to the leads, and due to emf. produced by electrolytic action on the thermocouple leads. The ducts are usually very wet, and excellent insulation is required to avoid the errors mentioned.

Most of the measurements have to be made in empty ducts as it is not possible to pull a couple for any great distance into a duct occupied by a cable. However, thermocouples can be pulled into occupied ducts up to limited distances, but there is considerable uncertainty in the measurements as it is quite impossible to tell whether the couple is in contact with the sheath, the duct wall or neither.

The Largest Diesel Engine Ships

The Union Steamship Co. of New Zealand has ordered from the Fairfield Ship Building Co., in Glasgow, a two-screw Diesel motor passenger ship of about 22,000 tons, which will be furnished with four Sulzer two-stroke-cycle Diesel motors from 12,000 to 13,000 hp. total capacity. Besides the main machines, auxiliary Diesel motors to the extent of about 1,500 hp. will be installed, so that the aggregate Diesel engine power in the vessel will be around 14,000.

Hitherto the largest Diesel-driven ships have been of 5,000 shaft-hp., and were also driven by Sulzer two-strike-cycle motors. These two motors of 2,500 hp. each, at 85 r.p.m., are now on the testing block of the Sulzer Bros. at Ludwigshafen, and they are for the first German motor passenger ship of the North German Lloyd.

Oil-Engine Nomenclature

In a paper read by J. L. Chaloner before the Institution of Automobile Engineers in London and reproduced in *Engineering*, it was stated that entirely too much confusion existed by reason of the many type and trade names of oil engines. He stated that a study of the many different designs reveals the fact that they are all some modification of one of the few fundamental principles of oil-engine combustion. The old term of "hot-bulb" requires qualification, "Diesel" is perplexing and inaccurate, "semi-Diesel" is meaningless; "solid injection" is used for almost all types save the Diesel; "cold starting" is misleading; "high-compression" may refer to oil or gasoline engines; "crude oil" shows misrepresentation; "heavy oil" does not tell the whole story, and "refined oil" confesses a deficiency. Yet all the existing types can be allocated in accordance with definite ranges of pressure and methods of fuel injection.

For the purpose of ending this confusion, Mr. Chaloner suggested the following classification of liquid fuel internal-combustion engines:

I. *Gas Injection*—(A) Low-pressure engine: (1) The fuel is mixed with the requisite amount of air in a mixing chamber (carburetor or vaporizer). The mixture is drawn into the cylinder, compressed to a moderately low compression-pressure and fired. (Otto cycle, Clerk cycle). (B) Medium-pressure engine: (1) No representative type in existence. (C) High-pressure engine: (1) The fuel is pumped into a small passage leading from the cylinder to a vaporizer. The gas pressure produced by a small fraction of the charge in the vaporizer injects the main charge into the combustion chamber. (Deutz system, Steinbecker type, Krupp type.) (2) The fuel is fed or injected into a cup or secondary chamber adjacent to the combustion chamber and connected with it by a series of small holes or channels. The heat of compression ignites the volatile fractions of the fuel and the resultant gas pressure forces the main charge into the combustion chamber. (Brons system, Hvid type, Leissner type.)

II. *Air Injection*—(A) Low-pressure engine: (1) The compressed air injects the charge during the induction or the first part of the compression stroke. The mixture is compressed to a moderately low compression-pressure and fired. (Bellem et Brégéras system, Egersdörfer type.) (B) Medium-pressure engine: (1) Compressed air injects the charge split up into main and auxiliary spray. The latter passes over a hot surface and meets the main spray in the combustion chamber. (Blackstone system.) (C) High-pressure engine: (1) Compressed air injects the charge towards the end of the compression. The compressed air may be generated by the action of the main piston as distinct from an independent compressor. The fuel charge may be kept separate from the compressed air. (Diesel and Clerk cycle, Trinkler and Haselwander systems, Körting and M. A. N. types.)

III. *Mechanical Injection*—(A) Low-pressure engine: (1) The charge is injected by pump pressure into the combustion chamber during compression and fired either by electric spark or hot surface. (Priestman system.) (B) Medium-pressure engine: (1) The charge is injected by pump pressure into the combustion chamber at the end of the compression, directed toward a hot surface, which introduces the ignition. (Ackroyd system, Rundlöf type, Crossley type.) (C) High-pressure engine: (1) The charge is injected by pump pressure into the combustion chamber at the end of the compression. The heat of compression ignites the charge. (Vickers, Ruston, Campbell and Doxford systems.)

The Chaloner classification makes mention of representative type engines of European manufacture. Applying this system to American engines, under Gas Injection, Class *C*, type 2, would fall the several Hvid engines of American manufacture, the Leissner, the two-stroke-cycle Worthington engine, the Western Diesel, as well as a number of others.

Air Injection, Class *C*, would embrace all the Diesels using air for fuel injection. Under Class *B* would fall the De La Vergne type FH engine.

The classification, Mechanical Injection (*B*), would include the engines now known as "Semi-Diesel" while in the (*C*) class would fall such engines as are usually termed "solid-injection," including the De La Vergne type S. I., the Ingersoll-Rand P.R. engine, the Otto and the Sun Shipbuilding Co. engine.

It would seem that a general adoption of the classification outlined by Mr. Chaloner would eliminate a good deal of the confusion which a person experiences who, when upon entering the market for an engine, is confronted with numerous type or trade names, many of which, as the semi-Diesel, is a play on another type name.

Central-Station Power in Canada

With a water-power development of 315 hp. per thousand population Canada stands well to the fore in respect to availability and utilization of hydro-power resources, being surpassed on this basis by Norway alone. The available and installed water power as compiled by the Dominion Water Power Branch and reported in the Census of Industry, 1920, recently issued, is as follows:

Province	Available 24-hr. power at 80 Per Cent Efficiency: At Ordinary Min. Flow Hp.	At Estimated Flow For Max. Dev. (Dependable For 6 Mo. Hp.)	Turbine Installation, Hp.
British Columbia	1,931,142	5,103,460	305,315
Alberta	475,281	1,137,505	33,187
Saskatchewan	513,481	1,087,756	.....
Manitoba	3,270,491	5,769,444	104,147
Ontario	4,950,300	6,808,190	1,212,650
Quebec	6,915,244	11,640,052	1,105,385
New Brunswick	50,406	120,807	30,180
Nova Scotia	20,751	128,264	46,948
Prince Edward Island	3,000	5,270	1,869
Yukon and Northwest Territories	125,220	275,250	13,199
	18,255,316	32,075,998	2,762,880

In Manitoba, Ontario, New Brunswick and Nova Scotia commissions under the government have been formed to develop or purchase power and to transmit and distribute electric energy. The greatest development in this field has been in Ontario through the Hydro-Electric Power Commission, which is delivering power to 222 municipalities and operating plants having an installed capacity of over half a million horsepower.

Kilowatt-Hours Generated per Kilovolt

The average kilowatt-hours generated per kilovolt-ampere capacity are interesting. In the Ontario stations there was an output of 4,714 kilowatt-hours per kilovolt-ampere capacity. With a power factor of 100 per cent this means that the equipment was utilized throughout the year at 54 per cent of its maximum capacity, or, using a power factor of 80 per cent, at over two-thirds its maximum capacity.

A total production of 5,894,867,000 kw.-hr. gives an average of about 680 kw. per capita for Canadian central stations as compared with 412 for the United States. The comparison of hydraulically developed power per capita is even more favorable to Canada, according to the Census,

		Total Power Equipment (excluding Auxiliary Plant Equipment): Total 1920	Commercial 1920	Municipal 1920
Total Primary Power	Hp.	1,897,024	1,415,488	481,536
Waterwheels and turbines	No.	594	454	140
	Hp.	1,754,130	1,370,496	383,634
Steam reciprocating engines	No.	196	102	94
	Hp.	49,430	25,572	23,858
Steam turbines	No.	37	12	25
	Hp.	80,750	16,039	64,711
Gas and oil engines	No.	179	95	84
	Hp.	12,714	3,381	9,333

being 660 kw.-hr. per annum for Canada as compared with 153 kw. for the United States. In Canada 97.2 per cent of the total electricity produced was generated by water power and 2.8 per cent by fuel, whereas in the United States for the same period only 37.1 per cent was generated by water power and 62.9 per cent by fuel.

Of the stations operating on fuel the average generating cost was 1.463c. per kw.-hr. Of this Alberta, with its coal mines and natural gas, showed the lowest—0.865c. per kw.-hr.

News in the Field of Power

Results of Lignite Carbonizing Experiments

Lignite Carbonizer Devised that is Simple in Construction and Low in Cost

THE Bureau of Mines has issued a report (Ser. No. 2441, February, 1923, W. W. Odell) on the results of lignite carbonizing experiments conducted at Grand Forks in 1922 by the United States Bureau of Mines and the University of North Dakota. The object of the investigation was:

To produce a well carbonized lignite; obtain a maximum throughout; note the influence of the quality of lignite used on the performance of the oven and on the character of the charbonized product; note the influence of the size of the lumps of lignite charged upon the character of product obtained and upon capacity; eliminate the smoke nuisance; study the performance of the cooler and the discharge apparatus, ascertaining facts relative to its adaptability in preference to other types; find out what the chief factors are that influence the production of a good quality of carbonized lignite, and make such changes in the oven structure as its operation indicated were necessary; note the character, quality, yield and size of particles of the carbonized lignite produced; and make certain laboratory studies during such delays in operation as are incidental to experimental work of this nature.

This program was carried out, but on account of the fuel situation and other factors, only a few different lignites could be tested. The same limitation applies to the study of the effect of sizes, but in spite of this the desired data relative to this factor are well in hand. Illustrations showing types of ovens and graphs to determine the influence of shutdowns and various costs of raw lignite and binder on the costs of lignite char and briquets are given. Summarizing the report says:

A lignite carbonizer has been devised that is simple in construction and in operation; the "first cost" of the carbonizer is relatively low; byproducts (gas and tar) are not recovered in the operation of this carbonizer, but with alterations in design they may be recovered, but probably will not be as valuable as the byproducts from other carbonizers are usually rated; the carbonizer may be operated intermittently without serious damage to it; the estimated cost and tentative layout of a plant of a definite capacity are given; the costs of lignite char and briquets made from lignite and binder of various prices are shown graphically; lignite char can be made at a much lower cost (approximately $1.25 per ton less) in this oven than in the byproduct ovens hitherto suggested for carbonizing lignite. This is chiefly due to the large capacity and low cost of the carbonizer.

Commercial Stocks of Coal in Storage in February

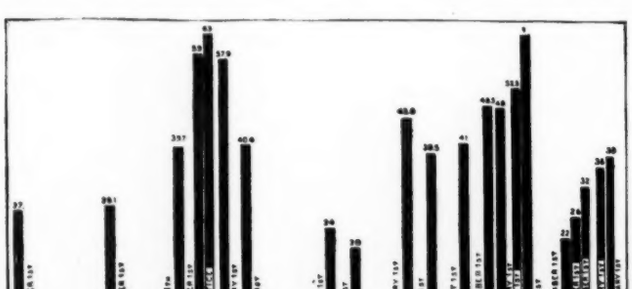
According to government reports on Feb. 1, 1923, commercial consumers had in storage approximately 38,000,000 tons of soft coal. This is 2,000,000 tons more than the stocks on Jan. 1, and represents a total increase of 16,000,000 tons since Sept. 1, 1922, when mining was resumed in the union fields that had been affected by the strike. The trend of production, however, during February was downward, and it is doubtful that stocks have increased perceptibly, if there has not been a decrease.

Reports from byproducts coke plants indicate that there is no longer a surplus quantity of coke in storage. On Feb. 1, there were 146,000 tons on hand, which represented only a normal working supply.

Stocks of anthracite in the yards of retail dealers on Feb. 1, were 13 per cent less than on Jan. 1. The quantity of anthracite on the Lake docks was 68 per cent less than on the first of the year.

It may seem surprising that only 2,000,000 tons were added to stocks in January, when production was nearly 4,000,000 tons more than in December. An appreciable part of the January production had not reached its destination on Feb. 1, and it therefore could not be taken into account in reckoning stocks. The most important factor tending to keep stocks from reaching a higher level was a sharp increase in the rate of consumption.

All available information indicates that the rate of consumption of soft coal in February was at least as large as in January, therefore in view of the downward trend in production, it is not thought probable that there was any great change in stocks on March 1.



TOTAL COMMERCIAL STOCKS OF BITUMINOUS COAL, OCT. 1, 1916, TO FEB. 1, 1923

Engineers Plan To Standardize Symbols and Abbreviations

The recent conference held in New York City under the auspices of the American Engineering Standards Committee indicates that there is a strong sentiment among the engineers, scientists, government officials, business-paper editors and industrial executives in favor of the unification of technical and scientific abbreviations and symbols.

Abbreviations and symbols are an important part of the language of technical men of today, and the use of one symbol or abbreviation for several different terms and the use of several different symbols or abbreviations for one meaning are causing a great deal of confusion, misunderstanding and serious errors.

In the development of the work it was agreed that the co-operation of foreign standardizing bodies should be sought, as uniformity in symbols is important on account of the international character of much engineering and scientific work and the importance of reference books and periodicals in foreign languages.

Announces a Conference on Superpower Plans for the Northeast

The next step toward the realization of the superpower plan in the Northeast, George Otis Smith announced on March 10, will be a conference between members of the superpower advisory board with representatives of the eleven state commissions having jurisdiction over public-utility matters. Commerce Secretary Hoover believes the most workable scheme to insure the co-ordination of these regulating bodies would be the drafting of an interstate treaty along the lines of the Colorado River Compact.

An early effort will be made to have a legal study undertaken of the existing state statutes or regulations which would interfere with or hamper the carrying into effect of the superpower project.

Holtwood Power Plant Will Be Completed

The Holtwood power station, of the Pennsylvania Water and Power Co. on the Susquehanna River, is finally to be completed. A contract has been given the I. P. Morris Dept. of the William Cramp & Sons' Ship & Engine Building Co. for the remaining hydraulic machinery needed, principally consisting of two 20,000 hp. Francis turbines. The addition of this equipment will increase the capacity of the station from 110,000 to 150,000 hp., for which it was originally planned. The present equipment consists of eight turbines.

The Holtwood station operates on an average effective head of 54 ft., the concrete dam being 55 ft. in height and half a mile long. The present battery of generators is of the three-phase 25-cycle type, with 11,000 voltage at the generator terminals. This is stepped up by transformers to 70,000 volts in the long-distance transmission lines.

Offers Research Graduate Assistantships

The Engineering Experiment Station of the University of Illinois maintains fourteen Research Graduate Assistantships. These assistantships, for which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics or applied chemistry. An appointment must be accepted for two consecutive collegiate years of ten months each, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Half of the time of a Research Graduate Assistant is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study.

Applications for appointment to these positions should be sent by April 1, 1923, to M. S. Ketchum, Dean of the University of Illinois, Urbana, Ill.

Seeks Information on Coal Grading

The Senate before adjourning adopted a resolution calling on the Bureau of Mines for the following information:

1. The result of such studies, particularly giving such information as would indicate the extent to which impurities and misgradings have been found in domestic sizes of anthracite coal.

2. What information the Bureau has as to the extent to which impure or misgraded anthracite coal of domestic sizes has been generally marketed to the public.

3. Whether or not it is the opinion of the Bureau that legislation should be adopted seeking to establish market grades as to the size and quality of anthracite shipped in interstate commerce.

Urges Study of Upper Delaware River

Merchants Association Sees Opportunity for Combined Water Supply and Hydraulic Development to Serve New York City

THAT New York City must develop additional sources of water supply within the next twelve or fourteen years, and that the upper reaches of the Delaware River is the most desirable watershed for this purpose has been asserted by the Merchants Association of New York City in a letter to Governor Smith, asking him to present the subject to the proper authorities in the States of Pennsylvania and New Jersey, in order that a joint commission of inquiry representing these states may be created.

Lying within sixty to seventy miles of the city and having an elevation of some 600 ft. above tidewater, such a development on the Upper Delaware would mean, the letter asserts, a supply of water adequate to meet the needs of the adjacent communities for many years, opportunities for extensive hydro-electric power developments, and the regulation of streamflow of the Delaware River below the proposed drainage area.

Although serious legal difficulties are anticipated by the association these are not considered irremediable. Clearly, says the letter in closing, the vast benefits of a combined water supply and power development on the Upper Delaware River can be realized only through the concurrent action of the three states concerned. To this end the association requests Governor Smith to do his best to bring about the creation of a joint commission of inquiry, in order that co-operation between the three states, similar to that now existing between New York and New Jersey in the matter of the development of the Port of New York, may become a reality.

Bills authorizing the appointment of such a joint commission have been introduced in the New York Legislature.

Approves National Hydraulic Laboratory

One of the last acts of the Senate Committee on Commerce prior to the close of the session, was to report favorably on the resolution providing for the establishment at Washington of a National Hydraulic Laboratory. The vote on the bill was unanimous. While there was no hope of the Senate's taking action at the time the report was made, the action of the committee will add to the prospects of the bill at the next session.

The Boston Society of Civil Engineers has strongly endorsed the establishment of a National Hydraulic Laboratory, claiming that the problems involved are of public interest and that the necessary scale makes impossible the undertaking of the study of the flow and regulation of rivers by educational institutions and that the object is not of a character to obtain industrial support.

Water-Power Projects

The American Super-Power Corp. has applied for a preliminary permit for two power dams on the St. Lawrence River, one near Waddington and the other near Massena, N. Y. The capacity of the two projects is estimated at 1,350,000 hp. The applicant proposes to market the power by a system connecting with power centers in Boston, New York, Philadelphia, Baltimore and Washington.

Messrs. Ernest Blue and Noel Traversy have applied for a preliminary permit to develop a power project near Hyder, in southeastern Alaska, a few miles from the Canadian boundary line. The applicants propose a diversion dam in the Soule Glacier River and a canal to a power house operating under a head of 250 ft. and developing 10,000 hp. The project is to supply hydro-electric power to Hyder and Stewart, British Columbia.

With the expiration of the two-year period, during which the water power act gives Congress an opportunity to consider any development which the federal government is likely to undertake, interest again is being manifested in the Great Falls project on the Potomac. Stinemann & Quick, of Baltimore, is the only interest which has actually applied for a preliminary permit covering that development, but it is understood that other interests are actively considering the project.

The Mount Shasta Power Co. is prepared to go ahead immediately with Pit River project No. 3, it is understood.

The Dixie Power Co. is now laying its plans for financing its three projects on the White River in Arkansas. The company has had Col. Hugh L. Cooper visit its sites and consider the general probabilities of the development. Colonel Cooper is said to be favorably impressed. The development of 150,000 hp. is involved, which will be marketed locally or in St. Louis and Kansas City.

The Federal Power Commission has applications covering projects in the Appalachian Range alone which aggregate 2,000,000 hp. This does not include the power possibilities of the Delaware, the Susquehanna and the Potomac, which represent more than a million horsepower in themselves. In the area bounded by the Clarion River on the north and the Tallapoosa River on the south, there are also many sites that have not been covered as yet by applications.

In the opinion of the chief counsel of the Commission the rights granted under a preliminary permit remain in force until the Commission acts on the application. The opinion will come before the Commission at its next meeting for approval. If approved, it will prevent the annoyance occasioned by renewals.

Society Affairs

The Boston Section of the Illuminating Engineering Society on March 30, 1923, will hear a paper by Dr. M. Luckiesh of the General Electric Co., on the "History of Artificial Illumination from the Dawn of Civilization to the Present Time."

Engineering Society of Wisconsin has elected the following officers: John C. White, chief operating engineer of the power plant of the state capitol, president; W. G. Kirchoffer, vice-president; L. S. Smith, secretary and treasurer, all of Madison, Wis.

American Engineering Council's Executive Board, F.A.E.S. announces through its president, Mortimer E. Cooley, a session for Mar. 22, at 8 p.m., Ohio Mechanics Institute, Cincinnati, Ohio. Among the subjects to be considered at the meeting Mar. 23-24 will be: Transportation problems in the United States, and upon the representation from the Associated General Contractors of America, the continued inflation of the building industry, which may result in a "buyers strike"; safety legislation; the use of machinery to relieve the labor shortage. The question of undertaking an intensive study of labor saving devices was referred to the A.S.M.E.

The A.S.M.E., A.I.M.M.E., A.S.C.E. and A.I.E.E. will hold a joint meeting of their Metropolitan Sections, March 21, at 8 p.m. at the Engineering Societies Building, 33 West 39th St. The subject will be hydro-electric power for New York and the availability and economics of hydro-electric power for the New York and New Jersey metropolitan district.

F. W. Scheidenhelm will speak on "Co-ordinating Statement of the Problem," W. S. Murray on "An Approximation of Available Water Power and Cost of Delivery," George A. Orrok on "Requirements of Service and Evaluation of Hydro Power," F. A. Allmer on "Quality of Hydro Service" and Lorin E. Imlay on "Reliability of Long-Distance Transmission." There will be a discussion by John P. Hogan, William Barclay Parsons and W. S. Finlay, Jr., as well as discussion from the floor.

The American Institute of Electrical Engineers will discuss central-station and industrial problems at their Spring Meeting in Pittsburgh, April 24-26. Luncheon at and inspection of the Westinghouse Electric and Manufacturing Co. at East Pittsburgh will be a feature of the meeting. The tentative program includes the following papers: "Survey of Lightning Disturbances on Distribution System," by M. McClaren; "Symposium on Reactors," by N. L. Pollard; "Breakdown of Cable Insulation," by J. L. Haydon; "Surges on Transmission Systems," by J. Slepian and J. F. Peters; "Third-Class Conductors and Mechanism of the Arcing Ground," by C. P. Steinmetz; "Systems Transmitting Generated Voltage," by P. H. Chase; "Systems Transmitting Transformed Voltage," by E. C. Stone; "Value of Resistance in Grounded Neutral," by H. H. Dewey; "Relay System of Duquesne Light Co. 66-kv. Ring," by H. P. Sleeper; "Ground Selector Relay Scheme," by P. Ackerman.

Coming Meetings

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Pacific coast regional meeting at Los Angeles, April 16-18; Spring meeting at Montreal, Canada, May 28-31.

American Society of Mechanical Engineers, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers and **American Society of Electrical Engineers**, 33 West 39th St., New York City. Joint meeting of Metropolitan Sections, March 21, 1923, at 8.00 P. M. Co-ordinated symposium: Hydro-Electric Power for New York-New Jersey.

Affiliated Technical Societies of Boston, 715 Tremont Temple, Boston, Mass. Meeting at Lorimer Hall, Tremont Temple, 7:45 p.m., March 28. Topic, Fuel and Power Problems.

American Chemical Society, Gas and Fuel Section; R. S. McBride, Colorado Bldg., Washington, D. C. Motor fuel symposium at New Haven, Conn., April 6.

Society of Industrial Engineers; George C. Dent, 327 S. La Salle St., Chicago, Ill. Spring convention at Cincinnati, Ohio, April 18-20.

American Institute of Electrical Engineers; F. L. Hutchinson, 29 West 39th St., New York City. Spring meeting at Pittsburgh, Pa., April 24-26.

American Welding Society, 29 W. 39th St., New York City. Annual meeting at New York City, April 27-28.

American Society of Refrigerating Engineers; W. H. Ross, 154 Nassau St., New York City. Spring meeting at St. Louis, Mo., April 30, May 1-2.

American Association of Engineers, 63 East Adams St., Chicago, Ill. Annual convention at Norfolk, Va., May 7-9.

American Water Works Association, 153 W. 71st St., New York City. Annual meeting at Detroit, Mich., May 21-25.

Stoker Manufacturers' Association; J. G. Worker, Eau Claire, Wis. Annual convention at Lake Placid Club, Essex Co., N. Y., May 29-31.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows:

Kansas, at Fort Scott, April 4-6; C. H. Taylor, 517½ W. 6th St., Topeka.

Business Notes

Pure Carbon Co., Wellsville, N. Y., announces the recent establishment of an Alabama representative, the Commercial Electric Sales Co., 1322 Empire Building, Birmingham, Ala.

Howell Electric Motors Co., Howell, Mich., announces the opening of a New York office at 17 East 42nd St., with R. W. Baker in charge as New York district manager.

Gifford-Wood Co., Hudson, N. Y., announces that A. W. Berghoefer, well known to the ice and coal trade, has again become associated with the company at its New York City office, 80 Church St.

Trade Catalogs

Ash Conveyor—Combustion Engineering Corp., 43 Broad St., New York City. Pamphlet describing and illustrating the Combusco Water Seal Ash Conveyor.

Water Softener—Graver Corporation, East Chicago, Ind. Bulletin No. 509. Describes the chemistry and the equipment of the Graver Zeolite Water Softener.

Boiler Tubes—National Tube Co., Pittsburgh, Pa. National Bulletin No. 12. Describes the properties, use and manufacture of the Shelby seamless hot-rolled boiler tubes.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Mar. 5, 1923	Mar. 12, 1923
Pool 1,	New York	$4.50–5.00	$4.25–4.75
Smokeless,	Columbus	4.25–4.75	4.25–4.75
Clearfield,	Boston	3.25–3.75	2.85–3.75
Somerset,	Boston	3.50–4.00	3.25–4.00
Kanawha,	Columbus	2.75–3.00	2.50–2.75
Hocking,	Columbus	2.50–2.75	2.35–2.50
Pittsburgh No. 8	Cleveland	2.90–3.15	2.85–3.00
Franklin, Ill.,	Chicago	3.25–3.50	3.25–3.50
Central, Ill.,	Chicago	2.50–2.75	2.50–2.75
Ind. 4th Vein,	Chicago	3.00–3.25	2.75–3.00
West Ky.,	Louisville	1.90–2.25	1.85–2.15
S. E. Ky,	Louisville	2.25–3.00	2.25–3.00
Big Seam,	Birmingham	2.00–2.25	2.00–2.25

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—March 15, Port Arhtur light oil, 22@25 deg. Baumé, 4⅞c. per gal.; 30@35 deg., 5⅛c. per gal., f.o.b. Bayonne, N. J.

Chicago — March 3, 24@26 deg. Baumé, $2.02 per bbl.; 32@36 deg., $2.39 per bbl. in tank cars.

Philadelphia—March 12, 26@28 deg. Baumé, Oklahoma, $1.05@$1.10 per bbl.; 30@34 deg., Oklahoma (group 3), 3¼@3⅜c. per gal.; 16@20 deg. Seaboard, $1.50@$1.60 per bbl.

St. Louis—March 6, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.07@$1.10 per bbl.; 26@28 deg., $1.15 per bbl.; 28@30 deg., $1.25@$1.30 per bbl.; 30@36 deg., gas oil, 5@5¼c. per gal.; 36@40 deg., distillate, 5½@5⅝c. per gal.

Pittsburgh—March 9, f.o.b. local refinery, 30@34 deg., fuel oil, 6¼c. per gal.; 36@40 deg., fuel oil, 6⅜c. per gal.; 34 deg., neutral, 10c. per gal.

Dallas—March 10, f.o.b. local refinery, 26@30 deg., $1.50 per bbl.

Cincinnati — Feb. 27, 26@28 deg. Baumé, 5⅝c. per gal.; 28@30 deg., 5⅞c. per gal.; 38@40 deg., distillate, 7c. per gal.

Cleveland — Feb. 27, 26@28 deg., Baumé, 6⅝c. per gal.

New Plant Construction

Calif., Antioch—The city received bids for the construction of a water supply system, consisting of two 250,000 gal. tanks, flume and pump sump, G. H. Field Co., Antioch, $12,340; two 2,000 g.p.m. horizontal centrifugal pumps, directly connected to two 20 hp. motors, United Iron Wks., 580 2nd St., Oakland, $2,750; furnishing and installing approximately 200 ft. of piping, fittings and one flow meter, Tieslay Bros., 2819 Grove St., Berkeley, $3,000. Noted Jan. 30.

Calif., Los Angeles—J. C. Austin, et al., Archts., Detwiler Bldg., are receiving bids for the construction of a 302 x 588 ft. auditorium on Jefferson and Royal Sts., for the Al Malaikah Temple, A. A. O. N. Mystic Shrine, 1210 South Hope St. Cost will exceed $1,000,000. Equipment detail not reported. Noted Nov. 15, 1921.

Calif., Los Angeles — The city, Bd. of Public Service will receive bids until Mar. 27 for electrical equipment, consisting of (1) potential transformers: eight 400 volt-amp. 50 cycle, ratio 300 to 1, oil insulated, indoor type, single phase potential transformers to be wound for operation on 33,000 voltage. (2) current transformers: single secondary: seven 300-150 to 5 amp., 60-30 to 1; three 600-300 to 5 amp., 120-60 to 1; six 1200-600 to 5 amp., 240-120 to 1: double secondary: fourteen 300-150 to 5 and 5 amp. ratio, 60-30 to 1; six 600 x 300 to 5 and 5 amp., ratio, 120-60 to 1. Transformers to be at least 50 volt-amp. capacity, 50 cycle indoor type, etc. Alternate proposals are invited.

Calif., Los Angeles—The County supervisors will receive bids until March 23 for the construction of a water system, including cast and wrought iron pipe and fittings; steel tank and tower; pumping equipment and accessories; water distributing system, pump house, pipe ducts and cleaning bed; iron body water valves; brass angle valves; steel A frame, near Compton.

Calif., Sacramento—R. A. Herold, Archt., Forum Bldg., will receive bids about Mar. 24 for the construction of a 5 story hospital on 40th and J Sts. for the Sisters Hospital, c/o Archt. Estimated cost $600,000. Equipment detail not reported.

Idaho, Lewiston—The city has had plans prepared for complete rebuilding of water system and extension, including 4,000,000 gal. storage capacity with filtration system, two reservoirs and cast iron mains. Estimated cost $400,000. Burns McDonald Eng. Co., Interstate Bldg., Kansas City, Mo., Engrs. Noted Nov. 21.

Ill., Astoria—The city, City Clk., will receive bids until April 12 for the construction of a complete water system, including 30,000 gal. impounding reservoir; 2½ mi. of 6 in. pipe; 200,000 g.p.d. rapid sand filter, two 200 g.p.m. motor driven pumps. Estimated cost $40,000. W. A. Fuller, 1917 Railway Exch., St. Louis, Mo., Engr. Noted Oct. 17.

Ill., Chicago—E. Edelman & Co., 469 East Ohio St., is in the market for electric motors, three 15 hp., one 10 hp., 850 r.p.m., one 10 hp., one 7 hp. 1150 r.p.m. and one 1 hp. 1750 r.p.m. All a.c., standard makes.

Ill., Urbana—The Bd. of Trustees of the Urbana and Champaign Sanitary District, Flat Iron Bldg., will receive bids until Apr. 16 for the construction of intercepting sewers, sewage treatment plant and appurtenances, including Division A, Sewers: 25,000 ft. of intercepting sewer, 8 to 30 in. in diameter, one inverted siphon and all manholes and appurtenances to serve 70,000 population; Division B, Sewage Treatment Plant: sewage pumping station, four primary settling tanks, sprinkling filters, conduits, buildings and appurtenances for a sewage treatment plant to serve about 45,000 population. Pearse, Greeley & Hansen, 39 West Adams St., Chicago, Ill., Engrs.

Ind., Jasper—The city will receive bids Mar. 21 for machinery and equipment for municipal light and water plant as follows: one 300 hp. water tube boiler; one 500 kw. turbo-generator set; one 500 kva. engine driven generator set; two centrifugal pumps and motors, to handle 800 g.p.m., 26 ft. head; one 5 x 125 ft. radial brick stack; steam piping; construction of addition to present building. J. R. Lowe, 111 North 3rd St., Louisville, Ky., Consult. Engr.

Kan., Kanorado—Rollins & Co., Engrs., 521 Ry. Exch. Bldg., Kansas City, Mo., will receive bids until March 27 for the construction of a 16½ mile transmission line from here to Goodland; also substations here and at Goodland. Estimated cost $25,000.

Kan., Topeka—The Topeka Hotel Co. is having plans prepared and is receiving bids on steel for the construction of a 10 story, 100 x 150 ft. hotel on 7th and Jackson Sts. Estimated cost $600,000. T. W. Williamson & Co., 312 Central Natl. Bank Bldg., Archts. Equipment detail not reported. Noted Oct. 10.

Kan., Wichita—L. R. Hurd, president of the Red Star Milling Co., and associates, plan to build a 1 story, 60 x 70 ft. power plant to furnish two units of the mills at 1901 North Emporia Ave. with electric power. Estimated cost $100,000. Contract for two 750 hp. Deisel oil engines and generating units has been awarded to McIntosh & Seymour Corp., 91 Orchard St., Auburn, N. Y.

Md., Baltimore—The Baltimore Ice Mfg. Co., c/o A. Beard, Pres., Hopkins Apartment, plans to build a 2 story, 60 x 165 ft. ice manufacturing plant at 409-11 North Exeter St. Estimated cost $175,000. Engineer or architect not selected. The owner is in the market for ice manufacturing machinery, 125 ton daily capacity.

Md., Baltimore—The Hebrew Hospital, L. Coblenz, Pres., c/o The Leader, Howard and Lexington Sts., plans the construction of a 7 story hospital on Monument St. between Bway. and Wolfe Sts. Estimated cost $800,000. J. E. Sperry, Calvert Bldg., Archt. Equipment detail not reported.

Md., Elkton—McCall's Ferry Power Co. is in the market for equipment, including boiler, generator, etc., for power plant at Gilpin Falls.

Mass., Boston—E. V. Earle & Sons, Inc., 200 Devonshire St., is having plans prepared for the construction of a 6 story, 100 x 150 ft. stores and warehouse building on Columbus Ave. and Clarendon St. Estimated cost $750,000. G. N. Meserve, 200 Devonshire St., Archt. Equipment detail not reported.

Mass., Cambridge — The Massachusetts Institute of Technology, 491 Boylston St., Boston, is having preliminary plans prepared for the construction of a 2 story, 100 x 150 ft. gymnasium, including running track, swimming pool, lockers, auditorium, etc., here. Estimated cost $1,000,000. Probably private plans.

Mich., Detroit—S. J. Murphy & Co., 1330 Penobscot Bldg., plans to build a 25 story, 120 x 150 ft. office building on Fort and Griswold Sts. Engineer or architect not selected.

Mich., Flint—The Bd. Educ. is having plans prepared for the construction of a 3 story, 175 x 350 ft. school building, including steam heating system with boilers and accessories, also plenum system of mechanical ventilation, for Intermediate School on the North Side. Estimated cost $750,000. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Detroit, Archts.

Minn., North Branch—The village, C. R. Swenson, Clk., is receiving bids for the construction of a waterworks system, consisting of 20,415 ft. of 4 to 8 in. pipe, 49 hydrants, pump house, 20 x 10 in. standpipe, etc. Estimated cost $30,000. C. L. Pillsburg Co., 1200 2nd Ave. S., Minneapolis, Engrs.

Mo., Kansas City—The Kansas City Life Insurance Co., Rialto Bldg., is having preliminary plans prepared for the construction of a 3 story office building. Estimated cost $500,000. Wight & Wight, 1st Natl. Bank Bldg., Archts.

Mo., Kirksville—The city voted a $260,000 bond issue for improvements to waterworks, including pumps, filtration plant, tank, tower and additions to distribution systems. Black & Veatch, 701 Mutual Bldg., Kansas City, Engrs. Noted Feb. 20.

Neb., Columbus—St. Mary Hospital, 313½ 13th St., is receiving bids for the construction of a 4 story, 45 x 150 ft. addition to hospital, a 2 story, 36 x 49 ft. dormitory and a 1 story, 50 x 90 ft. chapel. Estimated cost $250,000. C. Wurdeman Co., 313½ 13th St., Archt. Equipment detail not reported. Noted Feb. 28, 1922.

Neb., Randolph—The City Council is in the market for one 200 hp. semi-Diesel type engine. Estimated cost $16,000.

N. J., Glen Rock—The Mayor and Council, Smith-Singer Bldg., will receive bids until Apr. 2 for the construction of a sewerage system, sewage disposal works and a pumping station. H. J. Harder, 129 Market St., Paterson, Engr.

N. Y., Batavia—R. Saille, Elba Rd., is receiving bids for one complete large size lighting outfit, including generator, motor, etc.

N. Y., Buffalo—The Bd. Educ., 1401 Telephone Bldg., J. Storer, Secy., is in the market for two 15 hp. electric motors.

N. Y., Holley—The Holley Cold Storage Co. is in the market for machinery and equipment for large addition to cold storage plant.

N. Y., Kenmore—The Bd. Educ. is having plans prepared for the construction of a school building on Delaware Rd. Estimated cost $500,000. Kidd & Kidd, 524 Franklin St., Buffalo, Archts. Noted Feb. 6.

N. Y., Mount Vernon—The Eastchester Savings Bank, 9 South 3rd Ave., is having plans prepared for the construction of a 6 story bank and office building. Estimated cost $500,000. Holmes & Winslow, 134 East 44th St., New York, Engrs. and Archts. Equipment detail not reported.

N. Y., Rome—The Bd. Educ., W. B. Reid, Mayor, plans to build a high school. Estimated cost $500,000.

N. Y., Saranac Lake—The city plans the installation of a water pump. Estimated cost $8,500.

N. Y., Watertown—W. H. Cushman has been retained as consulting hydraulic engineer, to submit designs and prepare the specifications and contract for the Watertown municipal power.

N. C., Concord—The Gibson Mfg. Co. is having plans prepared for the construction of a large addition to its cotton mill, including installation of additional power facilities. Lockwood-Greene Co., Piedmont Bldg., Charlotte, Engrs.

N. C., Fayetteville — The Public Wks. Comn., H. J. McCuie, Secy., will receive bids until Apr. 5 for improvements to the city water works and sewerage systems, miscellaneous improvements to the pumping and filter plants, equipment of present filters with new manifold and strainer systems; rate controllers, loss of head and rate of flow gauges; furnishing and installation of one chlorinator, one motor driven centrifugal pump, one Venturi meter, etc.; construction of various structures, etc. W. C. Olsen, Kinston, Consult. Engr.

N. C., Wilmington—Carter's Production Wks., 210 South Front St., O. Carter, Mgr., is in the market for 30 and 50 hp. centre crank engines; five portable boilers, 25 to 40 hp.

N. C., Worthville—The Leward Cotton Mills, Inc., plans to double the capacity of their present plant, which is now approximately 5,000 spindles. This work will include building extensions, enlargement of village and the electrification of their present power plant. Lockwood, Greene & Co., Inc., Charlotte, Engrs.

N. D., New England—The city voted for the construction of an electric power plant, including one 37½ and one 75 hp. semi-Diesel engine; two generators, direct drive.

Ohio, Bellefontaine—The Citizens Ice & Supply Co. is in the market for ice manufacturing machinery. Noted Feb. 6.

Ohio, Cleveland—The Italian Home Bldg. Co., c/o P. Garbo, 13815 Drexmore Rd., is having plans prepared for the construction of a 4 story hospital and orphan asylum. Estimated cost $500,000. C. R. Greco, Guardian Bldg., Cleveland, Archt. Equipment detail not reported.

Ohio, Columbus — The Cast Stone Co., 1427 North High St., manufacturer of cement products, H. Price, Mgr., is in the market for three or four 25 hp. motors to operate plant.

Ohio, Columbus—M. L. Yuster, Parkview and Broad Sts., is having plans prepared for the construction of an 8 story, 80 x 86 ft. office building, on 4th and Broad Sts. Estimated cost $500,000. F. L. Packard, 16 East Broad St., Archt. Equipment detail not reported.

Okla., Okmulgee — Smith & Senter, Archts., Commercial Ins. Bldg., will receive bids about May 1, for the construction of

a 9 story, 100 x 140 ft. hotel on 3rd and Morton Sts., for The Creek Hotel Co. Estimated cost $1,000,000. Equipment detail not reported. Noted Nov. 21, 1922.

Ohio, Marysville—The Dept. of Public Welfare, 9th and Oak Sts., Columbus, will receive bids until Apr. 4 for the construction of a 1 story, 48 x 60 ft. power plant at the Reformartory for Women, here. Estimated cost $20,000. R. S. Harsh, Ohio Hartman Bldg., Columbus, Archt.

Ohio, Toronto—The Bd. of Trustees of Public Affairs, Municipal Office, will receive bids until Apr. 10 for the furnishing of materials, labor and equipment and the construction of a water filtration plant, consisting of two 1,000,000 gal. per day mechanical filter units, with auxiliary works, including one 2,000,000 gal. per day motor driven centrifugal high-lift pump, one 2,000,000 gal. per day motor driven centrifugal low-lift pump, electrical installations, piping and other appurtenances. Hudson & Myron, 808 Wabash Bldg., Pittsburgh, Pa., Engrs.

Pa., Allentown—J. L. Lordan plans the construction of a 5 story warehouse building on 16th St. Estimated cost $400,000. Engineer or architect not annonuced. Owner is in the market for cold storage and refrigeration equipment for perishable department.

Pa., Chestnut Hill (Phila. P. O.)—F. V. Nickels, 15 South 21st St., Phila., Archt., is receiving bids for the construction of a 1 and 2 story, 189 x 285 ft. ice manufacturing plant, for the Glen Willow Ice Co., 4511 Main St., Manayunk, Phila. Estimated cost $250,000. Equipment detail not reported.

Pa., Erie—The Erie County Milk Assn. plans to build a 2 story, 52 x 87 ft. power house at its plant on Peach St.

Pa., Kane—The Walker Creamery Products Co., 300 Union St., Warren, is in the market for cold storage machinery and equipment for plant here.

Pa., McKees Rocks—W. L. Singer Ice Co. is in the market for ice manufacturing machinery and equipment to replace that destroyed by fire.

Pa., Merion—P. Cret, Otis Bldg., Archt., is receiving bids for the construction of a 1 and 2 story, 50 x 156 ft., 48 x 68 ft., 21 x 24 ft. and 52 x 92 ft. art museum including steam heating system, for Dr. A. Barnes here. Estimated cost $1,000,000. Equipment detail not reported. Noted Feb. 6.

Pa., Norristown—The Montgomery Ice & Coal Co. is in the market for ice manufacturing machinery and coal handling equipment, to replace that destroyed by fire.

Pa., Phila.—R. A. Heyman, 215 South Broad St., is receiving bids for the construction of a 16 story, 90 x 135 ft. apartment building including vapor heating system, on 19th and Walnut Sts. Estimated cost $1,000,000. L. B. Rothchild, 215 South Broad St., Archt.

Pa., Phila.—The Phila. Enquirer, 1109 Market St., will soon award the contract for the construction of an 8 story, 93 x 395 ft. office and publishing plant, including steam heating system on Callowhill and Broad Sts. Estimated cost $750,000. Rankin, Kellogg & Crane, 1012 Walnut St., Archt.

Pa., Pittsburgh—The B Nai Israel Congregation, c/o B. A. Licker, 5466 Jackson St., is having plans prepared for the construction of a 1 story synagogue, 120 ft. long, at 327 North Negley St. Estimated cost $500,000. Sharove & Friedman, Berger Bldg., Archts. Equipment detail not reported.

Pa., Shinglehouse—A. Hartman, Arlington Hotel, Engr., is receiving bids for the construction of a silk mill, including 52 x 102 ft. main building, 24 x 30 ft. engine room and 36 x 40 ft. boiler room, for a company organizing.

Tenn., Chattanooga — The Chamber of Commerce is having plans prepared for the construction of a hotel to contain 300 rooms, on Lookout Mountain. Estimated cost $1,200,000. McKim, Mead & White, 101 Park Ave., New York, N. Y., Archts. Equipment detail not reported.

Tenn., Hohenwald—The City, T. J. Petway, Mayor, plans to build an electric power plant.

Tex., Belton—The Belton Ice & Refrigerating Co. plans the rebuilding of a 2 story ice plant to replace one recently destroyed by fire. Estimated cost $65,000. Engineer or architect not announced.

Tex., Dallas—The Texas Textile Co., c/o J. P. Burrus, Pres., McKinney, is having plans prepared for the construction of cotton mills at Love Field, here. Estimated cost $1,000,000. L. W. Roberts, Jr., Candler Bldg., Atlanta, Ga., Archt. Equipment detail not reported.

Tex., Houston—The Rice Institute, Commercial Bank Bldg., has had plans prepared and will soon receive bids for the construction of a 3 story chemistry building. Estimated cost $1,000,000. W. W. Watkins, Scanlon Bldg., Houston, Archt. Equipment detail not reported.

Tex., Stamford—The West Texas Utilities Co. is having plans prepared and will soon receive bids for the construction of a 2 story power house, including engines and generators. Estimated cost $90,000. S. E. Morley, c/o owners, Archt.

Tex., Waxahachie—The Shamrock Oil Co. is in the market for a 20 hp. gasoline engine.

Va., City Point—The Wilson Hock Co. is in the market for 200 kva. 2,300 volt 3 phase 60 cycle alternator, not over 260 r.p.m., also 400 hp. left hand Corliss engine to operate at 125 r.p.m. 140 lbs. steam pressure.

Va., Norfolk — W. H. Taylor, Director Public Wks., will receive bids until Apr. 2 for one horizontal water tube boiler, of approximately 225 hp., complete with setting on purchaser's foundation. D. H. Maury, 1445 Monadnock Block, Chicago, Consult. Engr.

Wash., Everett — The city, C. Klapp, Water Supt., has had plans prepared and will soon receive bids for the construction of a reservoir for city water system, including basin, 400 ft. square; sub-drainage system; reservoir, 20,000,000 gal. capacity; external equipment to include control house, baffle spillway, outlet and intake lines.

Wash., Okanogan—G. A. Shamberger et al., Tonasket, plan the development of hydro-electric power by plants on the Similkameen and Okanogan Rivers in Okanogan County. The owners are engaged in entering into contract with the ranchers along the Okanogan valley to furnish power to pump water for irrigation purposes. J. L. Broderick, Engr.

W. Va., Paw Paw—G. S. Fuller is in the market for complete equipment, including generating units for installation in local electric light and power plant.

Wis., Madison — The Hotel Wisconsin Realty Co., 86 Michigan St., Milwaukee, plans the construction of an 8 story, 130 x 180 ft. hotel on Fairchild and West Washington Sts. Estimated cost $900,000. Holabird & Roche, 104 South Michigan Ave., Chicago, Ill. Archt.

Wis., Madison—The University of Wisconsin, J. D. Phillips, Bus. Mgr., Administration Bldg., is receiving bids on (1) remodeling boilers room and setting one boiler, (2) one 125 hp. horizontal tubular boiler, including beams and channels for suspending boiler, (3) one hand operated stoker of 30 sq.ft. grate surface and furnace front. A. Peabody, Capital Bldg., Engr.

Wis., Madison—The Wisconsin Telephone Co., 16 South Carroll St., J. P. Brohany, Mgr., plans to build an addition to its telephone exchange building and to reconstruct pole, aerial cable, wire ground conduits and underground plant. Estimated cost $600,000. Engineer or architect not selected.

Wis., Manitowoc—The city, A. Zandler, Clk., is having plans prepared for the installation of additional equipment for water and light plant, consisting of two 400 hp. vertical water tube boilers, one 2,000 kw. steam turbo generator, underfeed foredraft side dump automatic stokers with all auxiliary equipment, including feed water heater, boiler feed pumps, steam flow meters, soot blowers and breeching. F. Alba, City Hall, Engr.

Wis., Milwaukee—The city, R. E. Stoelting, Comr. of Public Wks., will receive bids until March 23 for the construction of 1 story, 130 x 240 ft. superstructure for Riverside pumping station on Humboldt Ave. Estimated cost $1,500,000. G. Staal, City Hall, Engr.

Wis., Sheboygan—The St. Nicholas Hospital Assoc., c/o Sister Superior, 9th and Huran Aves., is in the market for refrigeration machinery for proposed new hospital.

Wis., Stanley—The Farmers State Bank, T. Gregerson, Cashier, is receiving bids on a new steam heating plant, including boilers for bank building. E. J. Hancock, Eau Claire, Engr.

Wis., Manitowoc—S. W. Randolph is having plans prepared for the construction of a 1 story, 125 x 400 ft. dock warehouse on the Inner Harbor. Estimated cost $75,000. W. J. Raenber, Manitowoc, Archt. The owner is in the market for electric power machinery, package conveyors, hoists, etc.

Wis., Wauwatosa—The Forsyth Leather Co., State St., plans to install coal and ash handling equipment in the proposed new power plant. Cahill & Douglass, 217 West Water St., Milwaukee, Engrs.

Ont., Sutton—The town, F. G. Tremayne, Clk., will install an electric light and power system this year under the supervision of the Hydro-Electric Comn. of Ontario, University Ave., Toronto. Wooden poles, cross arm and transformers will be required.

Ont., Peterboro — The Hydro-Electric Power Comn., 190 University Ave., Toronto, will have surveys and plans made for the development of hydro-electric power on the Trent Canal at Dams 8 and 9, about 30 ft. head, including power house, turbines, generators and electrical equipment, for the use of the city, here. F. A. Gaby, 190 University Ave., Toronto, Engr. Noted Jan. 9.

Ont., Toronto—The city, C. A. Maguire, Chn. Bd. of Control, City Hall, will receive bids until Apr. 10 for a 3,000,000 imperial gal. centrifugal sewage sludge pump directly connected to electric motor. R. C. Harris, City Hall, Engr.

CONTRACTS AWARDED

Calif., San Diego—The Hotel San Diego, 339 West Bway., awarded the contract for the construction of a 7 story, 100 x 110 ft. addition to its hotel to Lange & Bergstrom, Washington Bldg., Los Angeles. Estimated cost $450,000. Equipment detail not reported. Noted Mar. 6.

Calif., San Francisco — The city and county awarded the contract for furnishing, delivering and erecting structural steel for Moccasin Creek power plant of Hetch Hetchy project to the Union Constr. Co., Balfour Bldg., San Francisco, $60,720. Noted Feb. 20.

Ill., Chicago—Graham, Anderson, Probst & White, Archts., 80 East Jackson Blvd., awarded the contract for the construction of first unit of power plant for the Commonwealth Edison Co., Adams & Clark Sts., to the Geo. A. Fuller Co., 140 South Dearborn St. Estimated cost $3,000,000. Noted Feb. 20.

Ill., Chicago—A. B. Phillips, c/o E. E. Hall, Archt., 123 West Madison St., awarded the contract for the construction of a 4 story, 50 x 200 ft. apartment building at 3638-48 Sheridan Rd., to Nelson & Lind, 6404 South State St. Estimated cost $500,00. Steam heating system will be installed.

Minn., St. Paul—The St. Paul Gas Light Co., 6th and Cedar Sts., awarded the general contract for the construction of a 100 x 225 ft. generating plant and a 60 x 150 ft. pulverizing building on island in Mississippi River to the G. J. Grant Constr. Co., 906 Exchange Bank Bldg. Equipment detail not reported. Noted Jan. 9.

Miss., Gulfport—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., awarded the contract for refrigeration equipment for the U. S. Veterans Hospital to Clother Refrigerating Co., 61 Bway., New York. $19,480. Noted Feb. 6.

Mo., Kansas City—The Tri-State Realty Co. awarded the contract for the construction of a 6 story hotel and business building to the Pratt-Thompson Constr. Co., Republic Bldg., Kansas City. Estimated cost $700,000. Equipment detail not reported.

Ore., Portland — The Pacific Fruit & Produce Co., East 2nd and Alder Sts., G. Grouell, Pres., awarded the contract for the construction of a 2 story, 100 x 200 ft. warehouse and cold storage plant to Bingham & McClelland, 416 Worcester Bldg. Estimated cost $100,000. The owner is in the market for refrigeration machinery.

Pa., Phila.—H. Trumbauer, Archt., Land Title Bldg., awarded the contract for the construction of a 10 story, 50 x 136 ft. social service building at 307-11 South Broad St. to the Geo. A. Fuller Co., Morris Bldg. Estimated cost $1,000,000. Owner's name withheld. Equipment detail not reported. Noted Jan. 16.

Tenn., Johnson City—The Johnson City Hotel Co. awarded the contract for the construction of a 10 story hotel building to E. W. Minter, 115 Bway., New York. Equipment detail not reported.

Ont., Toronto—The Bell Telephone Co. of Canada, 76 Adelaide St., W., awarded the contract for the construction of foundation of 8 story (ultimately 12 story), 100 x 100 ft. telephone exchange building on Sheppard and Temperance Sts., to the Jackson Lewes Constr. Co., Ryrie Bldg., Toronto, $170,000; steel to the Dominion Bridge Co., Imperial Life Bldg., Toronto. Steam heating system will be installed; also automatic telephone boards and equipment to cost between $500,000 and $1,000,000.

T. H., Pearl Harbor — The Bureau of Yards & Docks, Navy Dept., Wash., D. C., awarded the contract for a refrigeration system at Naval Operating Base to Walker & Olund, 820 Piikoi, Honolulu, $18,796. Former contract rescinded.